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ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

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ANNALS *of* SURGERY

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THE MOST IMPORTANT FACTOR IN THE TREATMENT OF WAR WOUNDS AND THE MOST IMPORTANT FACTOR IN CIVILIAN SURGERY—THE GOOD SURGEON*

BY GEORGE W. CRILE, M.D.

OF CLEVELAND, OHIO

THE surgeons and the pathologists who for four years have intensively studied war wounds have formulated many theories of treatment—many apparently contradictory theories. Thus, there have been presented the claims of the value of various chemical agents against those of no chemical agent; of moist dressings against dry; of heat against cold; of frequent dressings against infrequent, and of no dressings against both; of sunlight and of electric light against occlusions; of immersion against hot air; of bacteriological control against clinical judgment; of vaccine toxins and foreign proteins against normal reaction; of wound inoculation with harmless organisms against wound sterilization; of isotonic against hypertonic solutions; paste has competed with paste; bipp with ip; sap with both; and chromic paste with all.

Does not this intensive study of infection in war wounds for this comparatively short period equal and recapitulate the more leisurely study of infection during the thirty years since Lister first proposed the carbolic spray? And is there not slowly emerging from the present conflict of opinions the same fact as that which emerged from the post-Listerian period—that the one agent of successful surgery, whether war surgery or civil surgery, is *the good surgeon?*

In civil surgery here in America, by what agency was mastery achieved over appendicitis, over cholecystitis, over tubal infection, over adenitis? What agent has contributed the most to the success of resection of the intestines and of the stomach; of gastro-enterostomy; of treatment of suppurating stone in the kidney; of treatment of infection of subcutaneous tissue? What agencies have achieved survival? One and but one—*the sound surgeon*, who always creates opportunity. Is it possible that in these four intense years of war surgery, in which more experience in traumatic surgery has been accumulated than during the past thirty years, we have traveled around the same circle as in civil surgery and have again found the same *surgeon?*

* Read before the American Surgical Association, June 16, 1919.

By sound surgery we mean the assumption of complete inclusive responsibility for every item that enters into the result; the consideration of the wound as well as the patient; the development of an ability to read the wound as well as the man aright. Sound surgery means quick, innocuous, timely intervention; it means seeing clearly the to-morrow of the wound; it means no intervention unless there is to be a net gain; it means a sharp knife, a good anæsthetic, a painless innocuous dressing; it means as much respect for the tissues of the anæsthetized man as those of the unanæsthetized man; it means a training in judgment that unerringly tells when to cut, how far to cut, when to quit cutting. It plays all the defenses and reparative forces of the patient. Good surgery is the exponent of no single method. It recognizes the anatomical and environmental situations in which chemical and physical agencies are useful. Good surgery exploits physiologic rest and fluids and sleep; it gives little pain. Good surgery evokes confidence; and confidence begets rest; and rest begets restoration. Good surgery, then, makes use of antiseptics and physical forces, just as it uses incision, counter-drainage, revisions, skin-grafting, blood-transfusion. Good surgery does not substitute an easy formula for its principles; above all, it always is dissatisfied with its work and always is open to suggestion.

What could the good surgeon accomplish with the wounds of war, with good opportunity but no antiseptics? Without antiseptics he could close by primary union a higher percentage of contaminated wounds than with antiseptics; he was able to remove damaged tissue with such accuracy that the natural defenses of the revised wound became its best antiseptic; he closed penetrated knee-joints more securely without than with antiseptics; he closed penetrated skulls without better than with antiseptics; he operated on perforated intestines more successfully without than with antiseptics; he cleared up foul and infected superficial wounds as well without as with antiseptics; he met gas gangrene with the timely use of the knife as well without as with chemical agents. He closed healthy superficial wounds with early suture tied lightly; healthy wounds that could not be closed by suture he closed by skin grafting, both as a healing and as a bacteriological policy; he closed fæcal and urinary fistulæ without antiseptics.

On the other hand, he realized equally that in compound fractures with or without bone infection, in deep, recessed wounds, in pyocyaneus infection in many other types of wound, that antiseptics might have great advantages, and he used them and used them well. In certain phases of a wound, he would use Carrel-Dakin; in another, acetic acid; in another, hot pack; in another, incision—a physiologic incision to-day to avoid the tissue tension of to-morrow; in another, transfusion; in another, sunlight or electric light; in another, continuous alcohol to make a scar covering.

In the rush of a great battle, he incised for drainage, and in addition he made "physiologic incision" to avoid the tension that is sure to follow the next day from the inevitable infection.

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But in quiet times, with microscopic exactness, he dissected out every atom of devitalized tissue. He read accurately not only the wound, but the patient; not only the patient, but the military situation; not only the military situation, but the condition of the infecting soil, the state of transport, his surgical assistance, and the type of nursing care—that is, he weighed accurately his chances for success. Therefore, the army medical service and the wounded man pinned their hope and their faith first, last, and always to the one agency of wound treatment that in civilian surgery emerged clearly from the confusion of the Listerian period; emerged clearly from the confusion of the four years of military surgery—*the sane, sound surgeon*.

THE PROBLEM OF THE "SLIGHTLY WOUNDED" IN MILITARY AND CIVILIAN PRACTICE *

BY WILLIAM E. LOWER, M.D.
OF CLEVELAND, OHIO

EVERYONE who has had the high privilege of participating in the World War must now be deeply concerned with a consideration of the way in which the lessons acquired in that vast experience may be adapted to the needs of civilian life. For the medical officers in particular the war has supplied a post-graduate course of untold value in organization, in transportation, in sanitation, in hospital construction, in the management of supplies, in the treatment of every variety and kind of wound by every variety of method, and—perhaps most important of all—in noting what *not* to do.

Among the infinite problems met by the medical officer in his experience both at the Front and at the Base Hospital, one of the most pressing was that presented by the slightly wounded man—the "walking wounded."

In rush periods, when large numbers of seriously wounded cases demanded the immediate attention of the medical officers and attendants, there was an inevitable tendency to neglect the still larger number of slightly wounded, or at the best to leave them to the attention of the comparatively untrained man, the most expert judgment being engaged with the apparently more urgent problems of the more serious cases.

This seemingly unavoidable neglect of the slightly wounded proved to be a dangerous hazard to the available man power and rapidly thinned the front line in certain periods of the war. The seriously wounded could be of no further service in the trenches, and it became of the greatest strategic importance that the slightly wounded should be returned to the line in the shortest possible time. Yet because of the pressure of numbers and the lack of early expert care, thousands of men with slight injuries became seriously infected and many died or were permanently disabled. The time factor in these cases was of supreme importance, and cases which under proper care could have been returned to the line within three weeks, were disabled for three months or more.

While it is true that the results of neglect of the "slightly wounded" in civilian practice cannot be computed on so gigantic a scale, nevertheless if all cases of apparently trivial industrial accidents which become infected as the result either of neglect on the part of the patient to report promptly or because of inefficient treatment, could be paraded annually, the size of this army of civilian disabled would be startling in the extreme. As they cannot be thus displayed and only isolated cases are noted no special impression has

* Read before the American Surgical Association, June 16, 1919.

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been made, and the consequent loss of life and limb and the economic loss to the community go on unchecked.

This is more true of the smaller than of the larger industrial centres, for the larger industries appreciate the value of the time loss of their employees and are constantly striving for a more efficient medical organization. Many of the great industrial plants have splendidly equipped medical departments under able advisors in which thousands of cases are treated annually. As a result, these plants report an extremely small per cent. of cases of infection which come from minor injuries. The greater number of casualties among the industrial wounded occur in the smaller centres, where there is no organized plan to provide proper care or where the surgical attendance is given by men of limited experience.

What may be accomplished by proper organization is well illustrated by the reports of Doctor Sherman, Chief Surgeon of the Carnegie Steel Company, who states in a recent letter:

The percentage of slight wounds which go on to serious involvement is almost nil where the patients report within a reasonable length of time for first-aid treatment at our emergency hospitals. Before these hospitals were properly organized and equipped, the percentage of infection varied considerably; at none of our plants was there less than 5 per cent. of the open wounds infected, while in some the percentage ran as high as 50. The reason for this was faulty organization and carelessness on the part of doctors and nurses. As a result of our campaign of education among our employees to report immediately for all minor accidents regardless of their nature, we have had very few serious involvements which have been due to accident. We have found that the ratio of infection where the patients received early first aid average 1 to 700. The vast majority of our cases that are infected come to us infected as a result of delay in reporting.

We occasionally have palmar abscesses, infections of the fingers, and sometimes a little lymphangitis of the extremities as a result of delay, but it is extremely rare that we see cases of amputation of legs or arms which are the result of insufficient early treatment. The reason for this is we have absolute control of all cases just as soon as they are injured, and have a competent corps of doctors and nurses and immediate attendance.

Investigation of this subject will reveal the fact that much of the infection is due to lack of coöperation of the large industrials and the medical profession, and the failure on the part of the latter to carry into practice in all its detail the same up-to-date surgical technic that is carried out in the average operating room. One would think that such a simple procedure as the aseptic and antiseptic treatment of simple wounds would be too primitive to permit of discussion, nevertheless, nine out of every ten doctors are very negligent in the treatment of these conditions.

It is not only in industrial plants, however, that we meet the problem of the "slightly wounded" in civilian life, for many of our hospitals have very inadequate provision for caring for minor injuries, and such cases are too often turned over to untrained and inexperienced operators.

The economic and the ethical importance of the proper care of punctured, incised, or lacerated wounds, practically all of which are contaminated and likely to become infected, has not been sufficiently emphasized. There is still too great a tendency to close such wounds primarily without proper cleansing,

rather than to leave them open and suture secondarily if the wound cannot be correctly disinfected at once.

This principle applies not only to the accident ward, but to the operating theatre as well, where the too frequent catastrophes following the so-called "slight" or "minor" operations testify to the neglect of some radical factor in proper treatment. In the great majority of hospitals "major" operations are most carefully governed by proper precautions. The operators are prepared for the possible emergency, an experienced, trained anæsthetist is employed, the principles of asepsis are rigidly observed. But the "minor" operations are too often undertaken by untrained and inexperienced men without proper guidance, regardless of the ever-present dangers of improper anæsthesia, of infection, of functional impairment; and the calamitous end results are out of all proportion to the small percentage of such results which could occur if every possible precaution were taken. Many practitioners are influenced by their patients who request surgical attention for some minor ailment, as they are not willing to suffer what seems to them a humiliation in refusing to perform the so-called minor operation.

Every surgeon recalls readily many occasions when he has been called upon to arrest hemorrhage after an inexpert circumcision or tonsillectomy; or to treat the serious and often fatal infection which has followed the removal of a corn, a uterine curettage, an attempt to remove an innocent looking tumor, or cutting into an aneurism, thinking it to be an abscess, etc. We are all familiar with cases in which functional impairment or loss has followed an attempt to remove a needle or other small foreign body without the aid of a properly taken X-ray picture and without sufficient aseptic precautions. We all know how the crippling results of transverse incisions of fingers or toes, of cutting tendons when abscesses are opened. We have seen too many cases of cellulitis following the removal of wens; and of the dire results of electrolysis in skin cases.

The catastrophes which may follow very serious imperative operations are often unavoidable and excusable; but the economic loss in time as well as the too frequent loss of life as a result of improper or delayed treatment, or of the inexpert performance of these minor operations under an untrained anæsthetist, have been too long endured.

What has been said regarding the treatment of the slightly wounded, may well apply to the average treatment of fractures. In spite of large experience in the treatment of fractures, we still see institutions which care for accident cases poorly equipped with proper appliances. We still note the transportation of fractured femurs and fractured arms without the application of proper splints. After witnessing the benefits secured in war casualties by the use of the Thomas splint, it would seem that every railroad and large industry, all ambulances and certainly all hospitals, should not only be plentifully supplied with this splint, but that all who are called upon to attend accident cases should be taught its proper application at least as far as transportation is concerned.

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With the recent vast experience in the treatment of the slightly wounded in war as well as of the seriously wounded, with the outstanding picture of the vital effect upon the firing line, of inexpert or delayed attention to the slightly wounded; with our civilian experience of the baneful effect of the neglect of minor cases in civilian surgery, does it not become the duty of this surgical organization to call emphatic attention to the need of proper organization in our civilian hospitals and in our smaller communities to assure better attention to the lesser as well as to the greater injuries, to the minor as well as to the major operation? Suffering and disability to the individual and economic loss to the community may thus be minimized.

WHAT WOULD BE THE BENEFIT TO THE CIVILIAN SURGEON IN THE EXPERIENCE GAINED BY OUR MILITARY SURGEONS IN THE RECENT WORLD WAR? *

BY EDGAR A. VANDER VEER, M.D.

OF ALBANY, N. Y.

ATTENDING SURGEON, ALBANY HOSPITAL

THE civilian surgeon who has not been able to take an active part in the late war, and who has had little experience with military surgery, with possibly the exception of dressing a few wounds in the Spanish-American War, must gain much additional knowledge from the splendid papers that are now being presented on this subject. He must make his final deductions from this analysis of war surgery, as it bears upon the treatment of severe railway and industrial wounds. This also applies to abdominal, thoracic and head injuries, as well as the treatment of fractures and hemorrhage.

To the surgeon of large civil and hospital practice the papers in our medical journals, for the first two years, would make it appear that the actual progress has been comparatively small. Our aseptic technic broke down early in the war, and, apparently, the surgeon was compelled to fall back on first principles and the antiseptic method. In his reading the civil surgeon has in mind the great number wounded by the fearful effect of high explosive shells, of air bombing, of long distance artillery, of machine guns, mines and shrapnel, the laying down of the barrage, and compares them to his own surgical practice. Then there are also the accidents occurring aboard steamers, from a diversity of causes, the crashing of falling buildings, and fire walls, the explosion of powder magazines, likewise the more fearful crushing wounds that come from the falling of heavy bodies, all these tending to produce great shock.

It is here that additional experience is sought in the method of procedure, particularly in railway surgery, industrial accidents and the immediate treatment of hemorrhage.

In the transportation of wounded we have an illustration that can well be followed out in the treatment of railway cases, in the principles embraced in our trans-Continental hospital trains. The method of transporting wounded soldiers from the place of injury, and for long distances, by motor, water or railway train, presents a lesson that can be made applicable in civil practice. For some time the civil surgeon meeting with these conditions has recognized the serious additional depression of long transportation in this class of wounded, as well as cases of acute hemorrhage, and has said in his own mind, and in discussion, it is better that I hasten to the wounded man than that he be brought so far to me. This additional

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exaction upon the patient's failing strength may be the last factor that terminates his case fatally.

The treatment of hemorrhage is one in which laboratory work, as well as the experimental efforts of many of our ablest civil surgeons, has resulted in great advances, but in the main will their conclusions be confirmed?

Have the excellent laboratories they had at the front made much clearer the subject of transfusion, either by the normal saline solution, and its modifications and the various preparations of blood, or the more direct, effectual and perfect method of blood infusion?

In the first and second years of the war the treatment of wounds, on the basis of the employment of sterile dressings, the sterilization of surgeon, patient, instruments, etc., left rather a cloudy, doubtful state of mind, in the civil surgeon, as to whether war surgery was accomplishing all that might be said of it, and in connection with our past knowledge of civil surgery. The loss of life from rapid infection following closed wounds, which became so serious, the loss of patients from tetanus—a condition that, in civil life, we felt was pretty well under control—the new kinds of wounds, from swift-moving heavy missiles at the same time shell wounds containing poisonous gases and trench fighting, which developed ground infection, all brought a shock to many an active civil surgeon, who had quite comforted himself with much better results than were early published regarding the treatment of wounds among the allied armies.

As a matter of fact in free suppuration and acute abscesses war surgery has not progressed much in advance of our other modern wars. We now know the cause of infection, but the treatment then was much the same as now.

Wounded are transported much more quickly than formerly, and are operated upon much more expeditiously, so that the risk of infection is less, but otherwise the treatment is much the same.

In the first years of the war it began to appear that the lower mortality rate was apparently due more to the treatment of diseased conditions of the men than to their surgical treatment.

Later, the prophylactic treatment of tetanus, the open treatment of serious wounds, the removal of tissue that would inevitably slough and cause infection, confirmed our experience in civil life. Here we felt that civil surgery was being paralleled, however, with this distinction, that war wounds, the serious nature to which I have referred, bring a more distinct line of injury to muscle, bone, nerve and circulatory system than the slow, crushing wounds of railway accidents, or the falling of heavy weights upon a limb in industrial injuries. In these cases many a civil surgeon was distressed to note the amount of serious infection and loss of life resulting in war surgery. We were not surprised to see a return to antiseptic surgery, the use of supposed germicides, and to note that the observing army surgeon, as reported from the active military hospitals in France, Belgium, and, to some degree, in England, were also experimenting in simply cleansing the wound, this line of aseptic treatment bringing better, and even excellent results.

Different methods bearing the name of eminent research workers, and laboratory surgeons, who have been able to carry their experiments into actual practice, are not yet so firmly grounded and present such uniform results as to convince the civil surgeon there is but one line of procedure, but one course to pursue in these cases.

Apparently the Carrel-Dakin method is of considerable benefit in the treatment of wounds of bones and joints, but it is very painful and the patients require large doses of morphine to make them comfortable. This and kindred methods are all good in their way, but much too complicated and costly to be used in ordinary civil hospital practice. Undoubtedly the Carrel-Dakin method is of much benefit when it can be carried out as planned by its author, but only a few civilian hospitals can furnish the nurses and attendants to do it properly.

Therefore, it seems to me the civilian surgeon may well continue the methods he has been accustomed to employ, and which have given him good results.

Reports from the large hospitals show that the wounded are still suffering from general sepsis a long time after the beginning of treatment, in spite of any of the methods employed.

The tests made, and the belief established that there must be a total absence of all pathogenic microorganisms from our field of operation when completed, and the wound ready for closure, have been given a severe trial.

It is possible, we must admit, that Nature is capable of doing a great deal in assisting the surgeon at this point, if she receives proper protection and encouragement by a not too severe antiseptic method.

Whatever we do we should constantly keep in mind our endeavor to obtain perfect wound healing, and surely this war has taught us that the pus-producing powers are always alert and ready to perform their unhappy intrusion in causing infection.

Any civil surgeon who has had an extensive practice and accustomed to being called to distant places in the country has been surprised to note the serious condition of the patient who had been injured less than twenty-four hours previously. Possibly the foot, leg or arm of the patient became entangled in the cutting bar of the mowing machine, or in some way in the reaper, or an open wound has been dragged over surface ground by some farm machine. In the former class of wounds, in going over the meadow, the surgeon was surprised to note how clean the grass or grain stubble appeared, or in the latter case the plowed ground would attract his attention regarding the possibility of infection from barnyard manure. In these cases he has also been surprised to observe how rapidly infection has taken place, and to find that already the lacerated wound of the arm, ankle or leg, with or without a fractured bone, had produced a swelling hardly to be realized in size; that when handling the parts there was to be noted a marked condition like that of emphysema of the chest, in a punctured wound of the lung. Recent work in the laboratory has told him that this is an infection

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caused by the bacillus aerogenes capsulatum, gas infection. If yet within the treatment of surgery it would perhaps mean the loss of the limb or immense sloughing or, at least, requiring free incision and drainage, while the serum treatment has seemed to do some good.

In the treatment of gas gangrene, it is hoped such a thorough trial will be made of Doctor Flexner's antitoxin as to bring us further and reliable data.

We were not surprised to hear of these war cases, and the term hospital gangrene had only a meaning of location. We have watched treatment with keen interest, and believe much credit is due some of our army surgeons for their exceedingly forceful, brave, operative intervention.

I believe I echo the opinion of many civil surgeons by emphasizing the belief that in the treatment of these cases something has been gained from the reports we have received to date through our medical journals, specially regarding the manner of doing the required amputations.

Then the civil surgeon reviews in his mind the final analysis in the use of anæsthetics; what additional knowledge will we acquire from the experience of our able war surgeons on this subject? We fancy, if we refer to the statistics of to-day, we are somewhat inclined to the belief that ether and chloroform have sustained their past reputation as anæsthetics, but, on the other hand, that the employment of nitrous oxide, together with oxygen, has found a substantial lodgment, and is to be respected in the treatment of shock cases, here bringing better results than have heretofore been deemed possible; that local anæsthesia has not advanced greatly in its application to military wounds is not disappointing. (Undoubtedly much good is to follow the careful study and presentation of papers by our returning surgeons, as well as the discussions that must inevitably result in such meetings as we are now holding in Atlantic City.)

Undoubtedly in the treatment of fractures important advances have been made. The use of the Thomas splint and methods employed by Doctor Blake and other surgeons have been of great benefit and have marked quite an advance in that direction. Also we have grown away from bone-plating and the use of artificial methods to encourage the healing of fractures.

The standardization of splints is likely to make a favorable impression, and be of great value. This is also applicable to the dressings accompanying the employment of the simplified and most practical splint, doing away with the frequent examination of wound dressings, and making transportation much more comfortable for the patient; however, in the actual use great care must be exercised, and joints watched, especially knee- and hip-joints regarding any malposition that may be produced.

Possibly, in connection with this work, we are to have more complete and exact results from X-ray investigation. More exact experts undoubtedly will develop radiographs that can be interpreted so clearly and convincingly to the civilian surgeon as to be of great help to the latter.

The report on the work of the X-ray laboratory at the front is likely

to present an amount of information that will be of great value to the surgeon in civil life.

In wounds of the abdomen, regarding the first suggestion of not operating until reaction had taken place, our surgeons have gone back to the original technic of operating as soon as possible after the receipt of the wound and with as little transportation of the patient as necessary. In this method of operating serious hemorrhage is controlled and the closing of the opening in the intestinal tract lessens negative traumatic peritonitis.

In the treatment of wounds of the chest we have learned much, and in my opinion that is the greatest advance which surgery has made in this war. Apparently it has been demonstrated that the thoracic cavity can easily be opened with almost as much impunity as that of the abdomen, joints or the brain. And it is along the line of thoracic surgery that our next great surgical advance has already been or will be made.

Of the major operations that have been performed in this war, it is believed there will be shown a much less percentage of amputations and that the recoveries in operations done within the abdomen will be greater than in any previous war. This will also embrace operations within the thorax.

In the operations about the head statistics thus far accumulating develop the fact that the steel helmet has certainly been a source of great protection, there being fewer scalp wounds and evidence of injury to the skull. Can we gain anything from this in protecting our industrial workers?

A factor of great importance presents in the reconstructive work that is being executed so thoroughly by and under the direction of the Surgeon General. The liberal appropriations made by the government enable the fitting out of assigned hospitals for doing this work on a more extensive scale than has yet been established by the generosity of private individuals or public hospitals.

The wounded soldier, as well as those yet suffering from the effects of army exposure and disease, is not permitted to his home until everything possible has been done for him.

It must be recognized that the United States Government has given to the Surgeon General's office a very generous amount of funds so that everything pertaining to up-to-date surgery and hygienic apparatus has been furnished.

The profession and public at large are hoping for great benefits to accrue to these wounded patriots, and in the final analysis the civilian surgeon must gather a vast amount of practical and valuable information.

Above all would the civil surgeon recognize the immense advance that has been made in the system of nursing, in the preparation of dressings, and through the Red Cross work by the women of America, who have worked so faithfully, so intelligently, so persistently in their efforts to help the American soldier?

RÖNTGENOGRAPHY OF THE BRAIN AFTER THE INJECTION OF AIR INTO THE SPINAL CANAL

BY WALTER E. DANDY, M.D.
OF BALTIMORE, MD.

(From the Department of Surgery, The Johns Hopkins Hospital and University)

As was shown in a recent publication,¹ one or more of the cerebral ventricles can be sharply outlined in a röntgenogram if the ventricular fluid be withdrawn and replaced by an equal quantity of air. In the course of this work it was soon noted that in many cases some of the air had passed out of the ventricular system and could be seen in filaments on the surface of the brain, that is, in the sulci. In order to reach the sulci from the point of injection in a lateral ventricle, the air must have followed the normal pathways by which cerebrospinal fluid circulates. It must have passed through the foramen of Monro into the third ventricles, thence into the fourth ventricles, through the aqueduct of Sylvius, and then, having left the ventricular system, it must have entered the cisterna magna by way of the foramen of Magendie and the paired foramina of Luschka. Finally, from the cisterna magna it must have passed along the various cisternæ under the base of the brain and then by numerous branches have reached the termination of the subarachnoid space—the sulci. Not infrequently, the entire subarachnoid space was graphically defined by the air shadows.

These observations at once gave promise of new possibilities in intracranial diagnostic study. Many lesions of the brain affect part of the subarachnoid space directly or indirectly. In hydrocephalus of the communicating type, adhesions at the base of the brain obliterate the cisternæ and the cerebrospinal fluid cannot reach the sulci over the cerebral hemispheres; a local area of subarachnoid space may be obliterated by a tumor situated on or near the surface of the brain; a defect in the brain due to atrophy must necessarily be filled with cerebrospinal fluid, which may maintain communication with the subarachnoid space. These, and no doubt many other conditions, should be demonstrable by the absence or by the presence of air over the cerebral hemispheres.

After the injection of air into a cerebral ventricle a certain amount will soon appear on the external surface of the brain if the head is carefully manipulated so that the air is guided to the small aqueduct of Sylvius and the fourth ventricle. But the time of escape of air from the ventricles and of its appearance in the cerebral sulci are variable. The more completely the ventricles are filled with air the greater the probability that it will appear externally; and the more dilated the iter and the foramina of Luschka and

¹ Dandy, W. E.: *Ventriculography Following the Injection of Air Into the Cerebral Ventricles*. ANN. SURG., July, 1918. *Fluoroscopy of the Cerebral Ventricles*. The Johns Hopkins Hosp. Bull., February, 1919.

Magendie (as in hydrocephalus) the more readily will air appear externally. Nevertheless, it was evident that at best the amount of air that will reach the cerebral sulci must vary greatly, according to the conditions existing in each individual case.

The problem therefore before us was: How can we in every case be sure of obtaining a complete injection of the subarachnoid space? The solution lies in the direct injection of air into the spinal canal. By this method the influence of the ventricular system is entirely eliminated; the air passes directly into the cisterna magna and thence into the ultimate ramifications of the subarachnoid space.

The technic is essentially similar to that described elsewhere for intraventricular injections. A small quantity of spinal fluid is withdrawn and an equal amount of air injected into the spinal canal. This process of substitution is repeated until the fluid ceases to appear on aspiration. There is no need to sterilize the air, because it is always free from pathogenic organisms.

Undoubtedly this procedure is not devoid of danger. Medullary distress, even fatal results, might well follow from increased intracranial pressure if the amount of air injected were even slightly in excess of the fluid withdrawn. The danger would certainly appear to be much greater in intraspinal than in intraventricular injections, because in the latter direct pressure on the medulla in large measure is inhibited by the tentorium cerebri. In my own cases no bad effects have followed and the results have led me to believe that with proper care and judgment the procedure is entirely harmless. I have always left the open needle in the spinal canal for two or three minutes after the injection has been finished, thus rendering the intraspinal pressure directly under control. If the needle is left open, the intraspinal pressure becomes equal to the atmospheric pressure, which is less than the normal intraspinal pressure. This reduced pressure is an additional safeguard against any possible development of a "reactive" intracranial pressure.

The position of the body is all-important in intraspinal injections—in fact, in all air injections, because the air rises as the fluid gravitates. The head must be at least twenty degrees higher than the needle. With each injection the air will then rush to the brain and a new supply of fluid will fall to the point of the needle. No doubt the sitting posture would be more satisfactory, because it would allow a more complete and uniform injection of the subarachnoid spaces over both cerebral hemispheres. In the recumbent position, which I have used exclusively, mainly for the comfort of the patient, it is possible that the injection may be more complete over the surface of the higher hemisphere than over the lower hemisphere, and that on turning the patient from one side to the other (in order to take both right and left lateral views of the head) important changes in the distribution of the air may be induced by the effects of gravity. In the sitting posture, rotation of the head would not alter the position of the air in the spaces, because gravity would not be brought into play, and a more accurate photograph

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of the "air mantel" on each hemisphere would be obtained. If, however, the intracranial subarachnoid space is thoroughly injected, there should be but little change due to gravity and the recumbent posture should prove practically as effective as the sitting posture. Additional experience will probably indicate the position of choice.

I have injected air intraspinaly into eight patients—four children and four adults—from Professor Halsted's service, without any bad effect. The amount of air has varied from 20 to 120 c.c. In one patient a mild headache followed but disappeared in three hours; vomiting but no headache occurred in another case; in the others no complaints were made. In reality, the effects should be much the same as those following the usual lumbar puncture.

One difficulty in the injection procedure should be mentioned. The aspiration must be gentle because the needle may plug at times, presumably with fibres of the cauda equina. If the suction is very gentle this may be obviated. In no case was there pain from injury to the nerves.

It must always be remembered that spinal punctures are very dangerous in all patients with intracranial tumors. A spinal puncture should never be made (if a tumor is present) unless the intracranial pressure has been previously relieved by a ventricular puncture or by some other procedure.

What becomes of the air? Air disappears from the subarachnoid space quite rapidly. It is absorbed as from other tissue spaces and undoubtedly passes directly into the blood. Usually no air is demonstrable in the röntgenogram twenty-four hours after the injection. Absorption from the subarachnoid space is many times faster than from the ventricles.

Practically all cerebrospinal fluid is absorbed from the subarachnoid space; very little from the ventricles, and the absorption of ventricular fluid occurs only after it has passed into the subarachnoid space.² When air is injected into a lateral ventricle, its rate of absorption seems to depend upon the freedom of access to the subarachnoid space. If the ventricles are normal the air will disappear in the course of a few days. If an internal hydrocephalus is present, the absorption time is greatly increased because an obstruction prevents the air from reaching the subarachnoid space. In cases of ventricular dilatation it may require two to three weeks for the air to disappear. The rate of absorption of air from the ventricles and the subarachnoid space appears to be relatively the same as that for the absorption of fluids from these cavities, although the absolute time required is greater for the absorption of air.

Röntgenography of the Normal Subarachnoid Space.—If the spinal and intracranial subarachnoid spaces are normal, the air which has been injected intraspinaly will fill all the intracranial spaces (Figs. 1-3). The cisterna magna shows as an air-filled space of varying size, anterior to the squamous part of the occipital bone. The cisterna chiasmatica, which is the anterior

² Dandy, W. E., and Blackfan, K. D.: Internal Hydrocephalus. *Am. J. Dis. Child.*, 1914, viii, 406. Second paper: *Am. J. Dis. Child.*, 1917, xiv, 424. Also: *J. Am. M. Ass.*, 1913, lxi, 2216.

terminus of the cisternæ, usually shows quite distinctly, and from it several branches may be seen passing upward into the cerebral sulci. The intensity of the shadow of the cisternæ under the medulla, pons, and midbrain is greatly modified by the dense bone at the base of the skull, notably the petrous part of both temporal bones. The continuity of the shadow of all the cisternæ can, however, nearly always be traced if the X-ray is good and the injection has been complete. The sulci appear as a network of lines over all the surfaces of the cerebral hemispheres. In general appearance the injected sulci suggest very closely the shadows of the vessels in the diploe, although the arrangement is different. In the earlier ventriculograms, in which only a few sulci contained air, the shadows were erroneously looked upon as markings of the diploëtic veins. Sulci have not been observed around the cerebellum, but frequently an envelope of air can be seen completely surrounding it. This envelope of cerebellar air is continuous with the cisterna magna. In one plate in which the upper part of the spinal canal was included, the spinal subarachnoid space was full of air, and in this column of air the shadow of the spinal cord was very distinct (Fig. 5).

The cerebellum frequently appears as an island (Fig. 3). Since the tentorium cerebelli is in apposition with part of the pericerebellar subarachnoid space, the shadow of this space marks the under surface of the tentorium. In cases in which the lateral ventricles are enormously dilated, a ventriculogram will delimit the upper margin of the tentorium. By combining the upper and lower shadows in such a case, the outlines of the tentorium are quite sharply seen. Mention of this is made merely to show how sharply the X-rays will differentiate tissues in a medium of air.

*Localization of Intracranial Lesions by Intraspinal Injections of Air.*³—The cisternæ may be regarded as the vital part of the subarachnoid space. Inasmuch as they form the trunk of the subarachnoid tree, all cerebrospinal fluid must traverse them in order to reach the cerebral sulci. The sulci are important because in them practically all cerebrospinal fluid is absorbed. Any obstruction in the cisternæ, therefore, leads to hydrocephalus because of a diminished absorption of cerebrospinal fluid. Hence it becomes of the utmost importance to determine whether the cisternæ are patent or whether they have been obliterated. Intraspinal air will always reach the sulci if the cisternæ are patent; and conversely, if the air does not reach the sulci, the cisternæ must be obstructed at some point. Furthermore, with a good X-ray one can see just where the obstruction is situated.

In this series of eight cases, the location of the lesion has been accurately determined in three. In the remaining five, the subarachnoid space was normal. In the three patients in whom the lesion was located by means of intraspinal air, other methods had entirely failed. The findings in these cases will be briefly stated.

³The röntgenographic detail in these plates we owe to the skill of Miss Mary Stuart Smith, in the X-ray service of Doctor Baetjer.

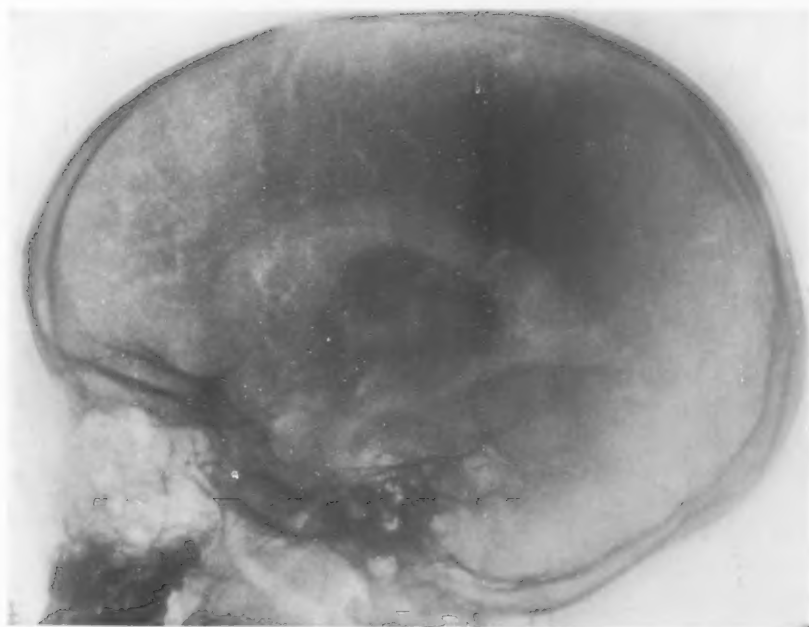


FIG. 1.—Photograph of a roentgenogram of the head after injection of air into a lateral ventricle. The air has passed out of the ventricular system and filled the cerebral sulci, which appears as a network of lines. The cisterna interpeduncularis and the major branches passing to the cerebral sulci are fairly distinct just above the sella turcica. The lateral ventricle is normal.



FIG. 2.—Photograph of a roentgenogram of the head after an intraspinal injection of air. The sulci and cisterna are more distinct than after the intraventricular injection as shown in Fig. 1.

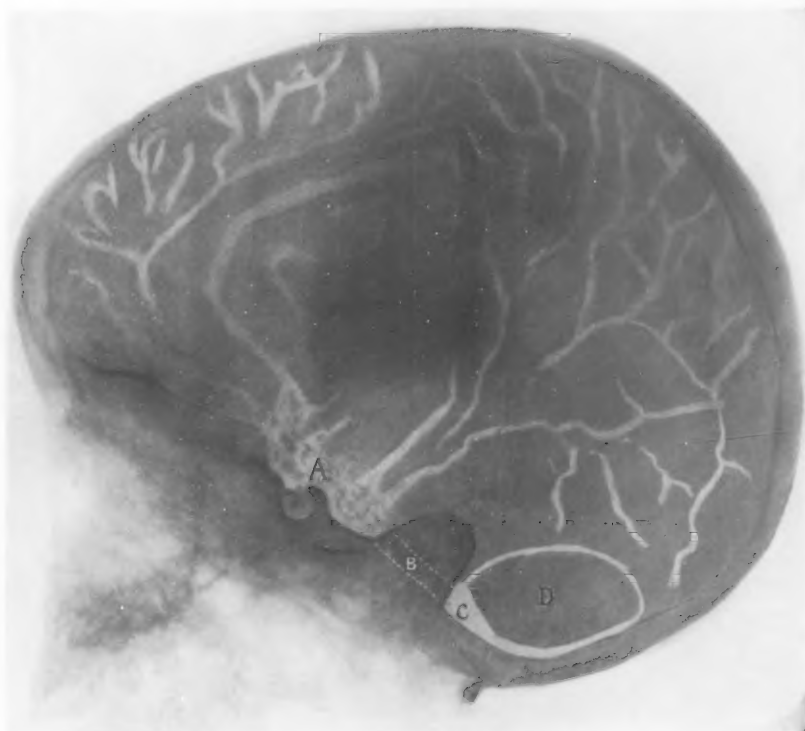


FIG. 3.—A retouched photograph of a roentgenogram of the head after an intraspinal injection of air. The subarachnoid space is probably normal. The lines of the component parts of the subarachnoid space have been intensified because of the loss of detail through photographic reproduction. A, cisterna interpeduncularis; from it many large branches can be seen establishing direct communication with the cerebral sulci. B, cisterna shadow subdued by the dense temporal bones. This part of the cisterna can be seen in many X-rays. C, cisterna magna; from it the cerebellar subarachnoid space completely encircles the cerebellum (D). The large horizontal sulcus shown directly connecting with the cisterna, in all probability, is on the mesial aspect of the brain and passes around the corpus callosum. It is impossible to tell which of the other sulci are median and which are external.

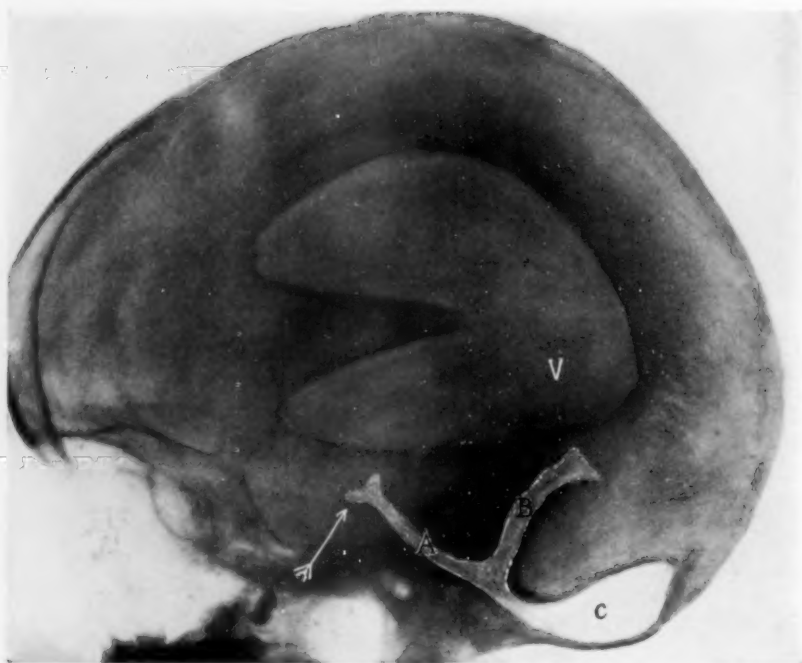


FIG. 4.—Retouched photograph of a roentgenogram of the head after an intraspinal injection of air. The patient had internal hydrocephalus. It will be noticed that none of the sulci are injected as in Figs. 1, 2, and 3. At the arrow, an obstruction due to adhesion has blocked the cisterna. A, cisterna pontis and medullaris. B, cerebellar subarachnoid space, also only partly open. C, cisterna magna, considerably enlarged. D, lateral ventricle, which partially filled with air after the intraspinal injection.

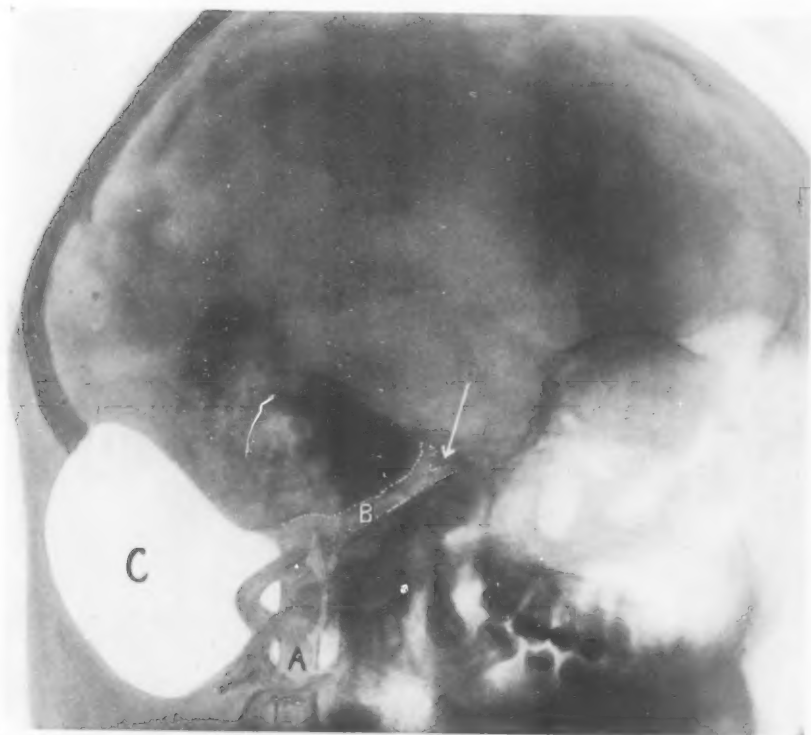


FIG. 5.—Retouched photograph of a roentgenogram of the head, after an intraspinal injection of air. The patient was suffering from the effects of an intracranial tumor which was localized only by the aid of the air injection and after a cerebellar exploration had revealed no growth. The operative defect in the occipital bone can be seen. In this region an enormous collection (C) of cerebrospinal fluid has accumulated. This corresponds to a greatly enlarged cisterna magna. Even the upper part of the spinal cord is visible because the spinal canal is filled with air. B, cisterna medullaris and pontis. The arrow points to the block in the cisterna. Here, a midbrain tumor was found and partially removed through a transcerebellar incision. It had closed both the aqueduct of Sylvius and the cisterna. The large collection of fluid (C) is due to the occlusion of the cisterna. It will be seen that none of the cerebral sulci contain air.



FIG. 6.—Photograph of roentgenogram of head after injection of air into ventricle (not retouched). This patient had an early hydrocephalus following acute cerebrospinal meningitis. Only a small area of the cerebral sulci contain air (cf. brackets between X and X on surface). The obstruction which caused the hydrocephalus was not in the cisternæ but in the main branches which radiate to the sulci. The arrow points to the cisternæ which appear as a series of "blotches"; part of this appearance is probably due to the dilated trunks (obstructed above) which pass from the cisternæ to the cerebral sulci. The partial filling of the cerebral sulci (X to X) explains the slow development of the hydrocephalus. C, cisterna magna.

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In a case of hydrocephalus, 110 cc. of air were injected intraspinously. It filled the cisterna magna, extended along the cisterna medullaris, and was stopped at the point of obstruction in the cisterna pontis (Fig. 4). This obstruction, due to adhesions from meningitis, had prevented the air reaching the sulci and thereby caused hydrocephalus. Necropsies have shown that communicating hydrocephalus is usually caused by adhesions in the cisternæ.⁶ I have since produced this disease in animals by occluding the cisterna with a perimesencephalic band of gauze.⁸

The injection of air gave still further information. Although it could not reach the cerebral subarachnoid space, which is normally the path of least resistance, it passed through the basal foramina of Luschka and Magendie, the fourth ventricle, the aqueduct of Sylvius, the third ventricle, the foramen of Monro, and partially filled a lateral ventricle (Fig. 4). The fact that the air passed into the ventricle showed that the hydrocephalus was of the communicating type. It should be noted that air has not been observed to enter the ventricle except in hydrocephalus. Normally, the cerebellum is in such close apposition to the floor of the fourth ventricle that, despite the absence of valves, the retrograde flow of air into the fourth ventricle is prevented. It is conceivable that the precise localization of the obstruction by the air method may render operative relief for the obstruction possible.⁹

Our second case presents an even more interesting pathology. The patient was a child three years of age. She had passed through an attack of acute cerebrospinal meningitis, but instead of complete recovery, lethargy and vomiting had ensued. Internal hydrocephalus was suspected by Doctor Blackfan, and confirmed by ventriculogram. A month later a second ventriculogram showed a measurable increase in the size of the lateral ventricle, but the rate of growth was markedly less than in the typical form of this disease. The air passed freely along the cisternæ and into the sulci over a very restricted area of the cerebral cortex (Fig. 6), not more than one-fourth of all the sulci showing the injection. Nor could it be determined whether the injected area was bilateral or unilateral. Exactly the same röntgenographic findings were present in the two X-rays taken a month apart; in fact, the same convolutions could be traced in both. The sulci could be followed into the cisterna chiasmatica.

These data supply a new conception of the pathology of hydrocephalus. The inflammatory process has sealed off all the main branches which radiate from the cisternæ, with the exception of one or possibly more which supply the anterior fourth of the cerebral cortex on one or possibly both sides. Absorption of cerebrospinal fluid from this restricted area has been sufficient to retard to a great extent, though not to prevent, the development of hydrocephalus. Should more branches from the cisternæ subsequently open, it is quite probable that, owing to the increased absorption which would follow, the accumulation of fluid will be entirely arrested. Such a development could easily explain many spontaneous cures in hydrocephalus. It is very doubtful if these pathological changes in the brain would be detected at necropsy.

A third case was in a boy of nineteen, who was suffering from intracranial pressure. An internal hydrocephalus was discovered. But what had caused the hydrocephalus? From his symptoms a tentative diagnosis of a cerebellar tumor was made, and since the signs and symptoms pointed to both sides equally, a vermis tumor seemed most likely. After a thorough cerebellar exploration I was unable to find any trace of the

⁶Dandy, W. E., and Blackfan, K. D.: Internal Hydrocephalus (second paper). *Am. J. Dis. Child.*, 1917, xiv, 424.

⁸Dandy, W. E.: Experimental Hydrocephalus. To appear in *ANNALS OF SURGERY*.

⁹In the December number of the *ANNALS OF SURGERY*, 1918, I presented a form of treatment for communicating hydrocephalus. If it should be possible, in a certain number of cases, to restore the channel of the cisternæ, this treatment would be superior to a bilateral choroid plexectomy.

tumor. The foramen of Magendie was normal. Three weeks after this operation, the phenolsulphonephthalein test showed that a complete obstruction was present at some point between the third ventricle and the foramen of Magendie. Air (120 c.c.), injected intraspinaly, was stopped in the anterior end of the cisterna pontis; none reached the cerebral sulci (Fig. 5). These findings could admit of only one interpretation—the pressure of a tumor in the region of the aqueduct of Sylvius, which had occluded it and the cisterna pontis. At operation a tumor as large as a hickory nut was found in the midbrain, and partially removed after bisection of the vermis of the cerebellum. The iter had been completely obliterated by the tumor.

Another interesting radiographic finding in the case was the enormous amount of fluid which had collected at the base of the brain after the first operation. We have frequently noticed after cerebellar operations in which a tumor was not found that such an accumulation of fluid followed, but the explanation had never been clear. The X-ray picture seems to indicate that the closure of the cisternæ causes the fluid to accumulate, or, in other words, bring about a localized hydrocephalus; the fluid forms in the fourth ventricle (the iter being closed). Another point of interest in this röntgenogram is the sharp outline of the spinal cord (Fig. 5).

A fourth case was that of a boy of eighteen. Hydrocephalus of a year's standing had followed an acute illness which had been diagnosed as measles. At operation the hydrocephalus was found to be due to closure of the foramina of Luschka and Magendie by dense adhesions. I made a new foramen of Magendie and wanted to be sure that it was functioning before allowing the patient to go home. Six weeks after the operation, air injected into the ventricles passed through the new foramen of Magendie and filled the cisterna magna and many of the cerebral sulci. We now could feel certain not only that the foramen of Magendie was patent, but also that all the subarachnoid space was receiving cerebrospinal fluid for absorption. The boy has since resumed his studies in college.

It also seems probable that we shall be able to localize spinal cord tumors by means of intraspinal injections of air. In one of our cases (Fig. 5) the spinal cord and the surrounding air-filled space are sharply outlined. Should the spinal canal be obliterated, either by a tumor or possibly by an inflammatory process, it is conceivable that the air shadow will extend up to the level of the lesion. Its intensity will naturally be greatly reduced by the great density of the spine, and particularly of the bodies of the vertebræ. A lateral view of the spine, by eliminating the maximum amount of bone, will probably give the best results. If the spinal canal is not obliterated by the tumor, the injected air will pass freely into the intracranial subarachnoid space, none being left in the spinal canal. This happened in one of our cases in which a spinal cord tumor was suspected. The passage of air into the brain was difficult to explain at the time of the injection, as the symptoms had been present for four years and a tumor of such duration would certainly have blocked the spinal canal. At operation a chronic transverse myelitis was found. Instead of an enlargement of the spinal cord, there was a constriction, which readily explained the failure of air to stop at the suspected zone.

As yet we have not had an opportunity of studying the radiographic findings in tumors of the cerebral hemispheres. It is conceivable that local effects may be noted in the sulci, or possibly even the direct or indirect effects of pressure on the cisternæ may be discovered.

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The practical value of intraspinal injections has been thoroughly established by the results in the few cases here reported. As a matter of fact, we shall often be able to localize a tumor from either a ventriculogram or from an X-ray of the subarachnoid space alone, an analysis of the signs and symptoms of the individual case enabling us to determine which should be tried first. From the data obtainable from the combination of intraventricular and intraspinal injections it is difficult to see how intracranial tumors can escape localization.

CONCLUSIONS

1. By substituting air for cerebrospinal fluid through a lumbar puncture, all parts of the subarachnoid space can be clearly seen in a röntgenogram.
2. Not infrequently, an air shadow will completely surround the cerebellum, showing clearly its size and shape.
3. The spinal cord can be seen surrounded by a column of air.
4. The cisternæ appear as large collections of air at the base of the brain; the cerebral sulci as a network of tortuous filaments of air.
5. After an intraspinal injection, provided that the subarachnoid space is intact, the air will always fill the cerebral sulci.
6. But if the cisternæ are blocked at any point by a tumor or adhesions, the air will not be able to reach the cerebral sulci.
7. The exact position of the obstruction in the cisternæ can often be seen in the radiogram. In one of our cases of communicating hydrocephalus, the obstruction was in the cisterna pontis. In a second case of communicating hydrocephalus the cisternæ were patent but all except one or two of the main branches were occluded. In a third case a tumor was located in the midbrain solely by means of the radiogram.
8. In a case of hydrocephalus, air passed from the spinal canal into the lateral ventricle, demonstrating the patency (and dilatation) of the foramina of Magendie and Luschka, the aqueduct of Sylvius, and the foramen of Monro. The hydrocephalus was, therefore, of the communicating type.
9. A case of hydrocephalus was cured by constructing a new foramen of Magendie. Six weeks later, air injected into the ventricles passed through the new foramen, showing that it was still functioning. The air also filled the cerebral sulci, an indication that the entire arachnoid space was patent.

EXPLANATION OF FIGURES

Much detail is lost in photographing and reproducing the figures. Figs. 1, 2 and 6 have not been retouched. Figs. 3, 4 and 5 have been retouched (even to the extent of being almost diagrammatic) in order to show clearly the essential details which otherwise would have been lost to the reader.

FRACTURE OF THE SKULL WITH SPECIAL REFERENCE TO ITS NEUROLOGICAL MANIFESTATIONS

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THE abundant opportunity afforded by the military emergency of studying injuries of the skull and brain has been put to such good use in affording us a newer conception of the possible neurological complications of fracture of the skull, that it has seemed advisable to review again a series of these latter injuries occurring in civil life, especially from the point of view of the neurological surgeon. The feasibility of making this comparison has been much amplified by the circumstance that during the past five years neurological cases—including skull fractures—have been segregated to a single service at Mount Sinai Hospital; more intensive study of individual cases has therefore been possible.

GENERAL INFORMATION

Incidence.—There have been 75 cases of fracture of the skull in the hospital in the last five years. This represents the incidence of these injuries in ordinary civil life in a district devoid of factories. The accidents practically invariably occurred in the vicinity of the hospital, to which the patients were brought, and the opportunity has, therefore, been presented for studying the clinical pictures from their very beginning.

The age and sex distribution is shown in the following tables:

Ages.—From 1 to 5 years, 20 cases; 5 to 10 years, 30 cases; 10 to 20 years, 4 cases; 20 to 30 years, 1 case; 30 to 40 years, 4 cases; 40 to 50 years, 3 cases; 60 to 70 years, 5 cases; unknown years, 5 cases. Total, 72 cases.

Sex.—Males, 54 cases (adults, 12 cases; children, 42 cases); females, 18 cases (adults, 3 cases; children 15 cases).

The great majority of the fractures occurred in the first decade of life, the larger proportion in the second half of this period. There were three times as many fractures in the male as in the female sex. This preponderance among children is not extraordinary, since most of our cases resulted from street accidents, or from falls into cellars or from the upper stories of buildings; both of these causes are apt to operate much more commonly in children.

Causes and Mechanism.—The actual mechanism of the fractures as determined from the table of causes has almost always been a direct blow. In many the fractured area was limited and lay directly under the point of application of the provocative cause; in the others the fissures

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extended over a wide area of the vault; or the injury was limited to the base, either unilaterally or symmetrically on both sides. Many of these were bursting fractures. It has never been possible to exclude the likelihood that some, at least, of the cases in the latter group were due to the direct impact of a line of force delivered through the lower jaw and its condyles, inasmuch as the patients were frequently unable to indicate accurately the part of the head struck, especially when the mechanism was part of a street car or automobile accident. The presence or absence of abrasions on the jaw or face is no absolute proof, either one way or the other, because the fracturing force may have been transmitted through the intermediation of some other part of the body (sudden and sharp forcible flexion of the head, the point of the chin striking the thorax).

CAUSES

Falls (into cellar; from upper story; striking curb) .	34 cases
Automobile accidents	16 cases
Blows	7 cases
Car accidents	5 cases
Unknown	10 cases

Location and Topography of Fractures.—The locations of the fractures have been as follows:

Frontal	9 cases
Parietal	15 cases
Fronto-parietal	6 cases
Fronto-parieto-occipital	1 case
Parieto-occipital	6 cases
Petrous and sphenoid	2 cases
Temporo-parietal into middle fossa.....	1 case
Temporo-parieto-occipital	4 cases
Parieto-mastoid	2 cases
Middle fossa	1 case
Posterior fossa into ear	1 case
Basilar	1 case
Not determined or noted in history	23 cases

Most of the fractures have been simple fissures; these have been of a variable length, frequently involving more than one of the bones of the skull. The direction of the fissures has usually tended to the vertical or oblique, those behind the coronal suture running downwards, or downwards and forwards, in the general direction of the middle cranial fossa, those in front of the coronal suture running downwards towards the anterior cranial fossa. In those who, for one or another reason, were subjected to operation, it was frequently found that the extent of the fracture exceeded the pre-operative expectations. In a small number the fissures assumed a transverse direction. In one case there were two parallel fissures about four inches long with a finger's breadth interval between, running through the frontal, parietal and temporal bones and about a finger's breadth above the auricle. In one of the cases the frac-

tured edges were separated by an appreciable interval and the dura projected between; in all the others this interval was lacking.

A knowledge of the topography of the fissures in the skull is of importance, inasmuch as it is the present consensus of opinion that the direction of the fissures is parallel to the lines along which the fracturing force is delivered; on occasion this may have a medico-legal bearing.

Comminution with depression was present in only eight of the cases. The depressions assumed especial significance in the neighborhood of the venous sinuses: complications then very commonly occurred which made operation imperative, the most frequent of these being hemorrhage and compression. In one other case there was much comminution in the vicinity of the parieto-occipital angle without depression; there were no symptoms or objective findings indicating the necessity for operation and the patient made an uneventful spontaneous recovery.

Coincident Brain Injury.—In the cases in which operation seemed necessary injury of the subjacent brain was very commonly found with and without laceration of the overlying dura. The extent of the damage done to the brain was frequently much larger than that to the skull; and the nature of the cortical injury gave one the impression that the major portion did not extend very deeply into the brain substance. From various sources the impression has been conveyed that in the post-mortem room injuries of the brain are frequently found on the side of the head opposite to that which had received the trauma; the most common combination to find is a fracture of the skull in the general neighborhood of one parietal eminence with or without an underlying brain injury, and a contusion or laceration of the cortex with more or less extensive hemorrhage in the general region of the tip of the opposite temporo-sphenoidal lobe. For injuries of this kind a *contre-coup* mechanism has been assumed. One such case has been met with in this series, of which the clinical notes follow:

Hospital No. 186858. An eight-year-old boy was brought to the hospital with an injury in the left parietal region. He rapidly became unconscious. Later he passed into a semiconscious state, vomited, was very restless, and, in his lucid moments, complained of frontal headache. There were irregular and unequal spastic convulsions in the left hand and right foot, the toes of the latter assuming a position of plantar flexion. There was a large hæmatoma in the left parietal region but no other evidence of the location of the injury could be discovered. The pupils of the eyes were unequal; in the right eye there was no reaction to light, and the fundus showed some hemorrhage and a beginning papilloedema; in the left eye the pupil reacted to light and the fundus showed a large hemorrhage. The extremities were alternately flaccid and spastic. The upper and lower reflexes were present, equal and not exaggerated; a bilateral ankle clonus and Babinski could be elicited.

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Operation was done four hours after the accident. The hæmatoma was opened and in its bottom a long fissure was seen in the parietal bone running backwards to the occiput; a button of bone was lifted out and, the dura appearing normal, the button was replaced and the outer wound was sutured. Then a right subtemporal decompression was done; here there was a large hemorrhage underneath an intact dura with a much lacerated and contused brain.

The operation was followed by an uneventful convalescence and on discharge from the hospital the neurological status of the patient was normal.

X-ray Studies.—Röntgenographic studies were invariably made in all of the cases except in those who were admitted in a moribund condition. In a small proportion of the patients the lines of fracture were not visible on the plates; this is probably so because in a fissured fracture the opposing surfaces can be so closely adapted to one another as to give no opportunity for a difference in texture sufficient to throw a distinguishing shadow on the X-ray plate. On one occasion this observation has been corroborated by the opportunity afforded by post-mortem examination.

When the fracture involved the floor of the skull in the region of the accessory sinuses, the lines of fracture were difficult, if not impossible, to make out because of the numerous planes of bony tissue which, crossing and overlying one another in an equally numerous number of ways, oftentimes created on the plate an uninterpretable picture.

Symptomatology—General.—The general symptoms of brain irritation were not always present and in those of our patients who were "neurologically negative" they were practically absent. In the others the range of variation was very wide. Vomiting was very frequent; most often it occurred within a few minutes of the injury; rarely was it repeated to any great extent, or did it last longer than the first twenty-four hours. Headache was nearly always present; in a few it was mild and evanescent; in much the larger number, however, it lasted for many days and in some for a number of weeks before it disappeared. It was generally of a diffuse variety, though in some it seemed to be at its maximum in the general region of the injury. Dizziness was a symptom that was rather rarely seen.

A loss of consciousness was not always described; this happened in the cases with scalp wounds in whom fractures were only determined later by the X-ray. Even among these, however, there were cases with a momentary loss of consciousness. In all the others there was either a transient or more persisting loss of consciousness; and corresponding with the presence and degree of concussion, of compression, or of both of these coexisting or succeeding one another, consciousness was recovered very quickly, or more slowly, or only temporarily to pass into a deeper stupor or coma. In those beginning to regain their normal func-

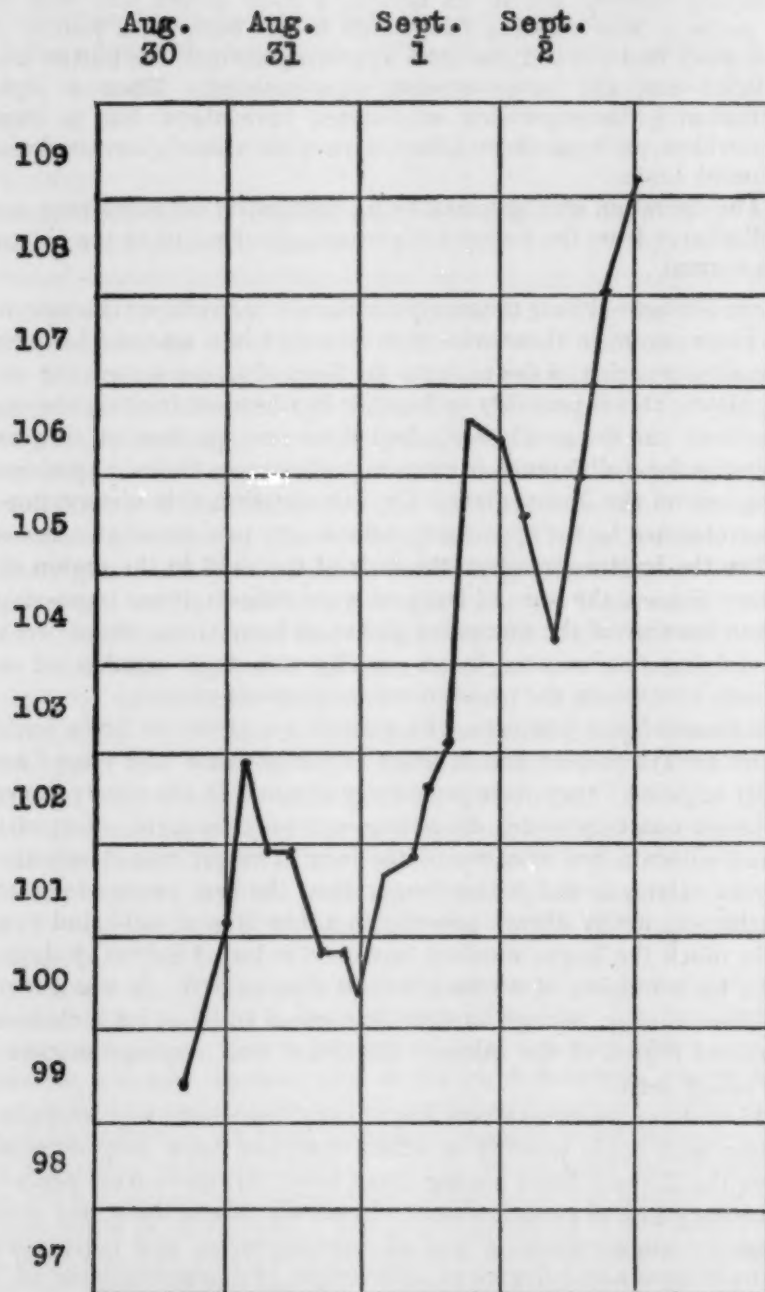


FIG. 1.—(Hospital No. 148405.) Temperature chart.

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tions, and in those doing so only temporarily, there was a stage in which cerebation was slow and sluggish so that it was difficult to elicit answers to questions, or to make the patient coöperate in any way necessary towards the accurate determination of the disturbances of neurological function.

A deep coma or stupor with stertorous breathing and with beginning involvement of the circulation was a matter of grave concern, since it indicated disturbances in the vital medullary centres.

Fever.—A number of the cases developed fever. This was present in the absence of any apparent source of infection. In one case the temperature rose to 106° F.; in another to 109° F.; both of the cases were operated upon but the rise in temperature was independent of the operation. Both of the patients died. I do not believe that the fever was an ante-mortem phenomenon. Two explanations are available: one, that some involvement of the heat centres took place—either primarily as a result of the trauma, or, secondarily, as a result of compression from oedema—which resulted in the extraordinary rise of temperature; or, possibly, some degree of encephalitis followed the contusion of the brain substance. Perhaps this was present in case No. 148405 in which operation demonstrated great intracranial tension and widespread oedema of the brain as evidences of an equally widespread contusion.

General Neurologic Symptoms.—Abnormal neurological phenomena were not always present in the patients in this series; and in 34 of the cases no symptoms or objective signs could be elicited which would indicate any disturbance of neurological function. These were practically always the mild cases, and among them one could distinguish the following: (1) Cases of scalp contusions or lacerations, with trivial or no symptoms and in whom fracture was originally not suspected but subsequently demonstrated by the X-ray in accordance with the routine custom of X-raying all cases of head injury of any kind. These made up the greater number of the "neurologically negative" cases. (2) Patients with such quickly disappearing symptoms that by the time the patients were admitted to the hospital and examined, evidence of any disturbance of neurological function could not be determined. All of these patients recovered, and, on discharge from the hospital, their neurological status was normal.

The remaining patients in this series of cases all presented some abnormality of the normal neurological status. There were all grades of disturbances; some were very mild and were elicited only by examination; others in which the grade of severity reached to a maximum. The effects of these disturbances also varied; in some the abnormalities were transient; in a few the consequences persisted at the time of discharge from the hospital. These effects were seemingly related to the pathology present in the involved area; transient symptoms were associated with localized (relieved) compressions by bone depression or

blood clot, or to temporary disturbances in the circulation, especially on the venous side, as will be pointed out later under the term "longitudinal sinus syndrome"; more lasting or permanent disturbances followed disorganizations of brain tissue due to the provocative trauma or to changes in the blood supply, or to division of major nerve trunks, or to unrelieved conditions (depressions, blood-clots, etc.) which would be apt to result in permanent pathological conditions. Illustrations of these latter conditions will be referred to later.

Concussion.—Twelve of the patients died within a few hours of the accident. It has been assumed that the violent injury had produced a high grade of disorganization of the brain substance sufficient to lead to a rapid death. The clinical pictures included a profound stupor, a high grade of shock, and a condition of the circulation which would have made futile any attempt at operative interference. Frequently there was marked oedema of the lungs within an hour of the injury. In a number there were more or less well-marked focal symptoms. In a few the possibility of an extraordinarily rapid intracranial compression from hemorrhage or oedema with a rapidly fatal involvement of the medullary centres could not be excluded.

Compression Phenomena.—Compression phenomena have been common. They appeared very quickly in most of the cases. An initial stage of concussion was not always present; or, if it were, it could not be distinguished in the severity of the general clinical picture. The cause of the compression was either intracranial hemorrhage, oedema of the brain substance, or both of these. It is very important to be able to recognize those of the cases of compression which are due to oedema—a desideratum which is not always easy of accomplishment—inasmuch as spontaneous recovery without any decompressive or other operation is a possibility. The notes of the following case are given as an illustration:

Hospital No. 191439. A four-year-old boy was brought to the hospital having been picked up on the street. No history of the accident was available. The patient was in deep stupor with noisy stertorous breathing and, altogether, looked very badly. Except for a small laceration of the forehead there was no evidence pointing to the location of the fracture. The pupils were widely dilated, although they still reacted to light, and in the fundi the disk margins were distinctly blurred, especially on the nasal sides. The kneejerks were hyperactive; otherwise there were no abnormalities. The systolic blood-pressure was 95 mm. Hg, and the diastolic was 65 mm. Hg; the pulse was 68 beats to the minute. There was no doubt that some compression was present, and the signs increased somewhat during the next few hours; nevertheless, a conservative policy was adopted. Twenty-four hours later there was distinct improvement and by the end of the third day the neurological status was normal.

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Whatever compression had been present was surely due to cedema which gradually subsided concomitantly with the return of the normal functions.

In other instances the compressive effects appeared more slowly. In one of the cases the development of the picture consumed three days. This occurred in a seventy-year-old man in whom the accident had resulted in a fracture of the skull, a fracture of the clavicle, and fractures of both bones of the leg. On admission he was in semistupor. There were no objective findings pointing to a focal neurological lesion and no signs of marked intracranial pressure. Signs of the latter, however, gradually grew more prominent during the course of the next three days, at the end of which time the evidences of compression dominated the clinical picture. The patient did not recover.

In judging of the severity of the increase in intracranial pressure the greatest reliance was always placed on the condition of the circulation, especially as indicated in the slowness of the pulse beat, in conjunction with the general condition of the patient and the condition of the eye-grounds. The average systolic blood-pressure found in the patients studied was about 110 mm. Hg, the range being between 90 and 140 mm. Hg; the average diastolic pressure was 73 mm. Hg, the range being from 55 to 100 mm. Hg; the average pulse pressure was 36 mm. Hg. Immediately upon admission the pressure tended to be low, as would naturally be expected from the associated condition of shock; improvement in the general clinical picture accompanied a rise in pressure; a progressive increase or a reappearance of compressive phenomena accompanied a progressive or secondary rise and a terminal fall in blood-pressure.

A marked increase in intracranial pressure has always been considered the most imperative indication for operation and the urgency of the latter was always in direct mathematical ratio with the speed with which the signs of increased intracranial pressure made their appearance and dominated the picture. Every effort was always made to operate before the signs of medullary involvement had made their appearance; any stage, beyond the most early, of compromisation of these vital centres creates a situation so serious and grave for the patient as to make any effort towards an operative relief of the compression futile.

Convulsions.—Generalized convulsions were present in one patient of this series. This was a female child of four years brought to the hospital in a comatose condition; no history of the accident was available. The little girl bled profusely from the pharynx and the diagnosis was evident. Generalized convulsions were present and were repeated until the child died forty-five minutes after admission to the hospital. No autopsy was permitted.

Reflexes.—The commonest evidences of neurological disturbance were found in the condition of the reflexes. These existed either alone, or as part of a clinical picture, such as that of a higher focal lesion, in which

the condition of the reflexes was apparently incidental. The response obtained might be equal or unequal on both sides; might be weaker than normal on one or both sides; or might be similarly exaggerated. In a number of the cases the ordinary reflexes could not be elicited immediately upon the admission of the patient to the hospital (*i.e.*, within a very short time after the accident), but very quickly they returned and then they were either normal or followed one of the variations described above. The important point seemed to be that frequently these abnormalities of the reflexes, in the absence of any other evidences of a focal lesion as indicated above, had no definite bearing in the total clinical picture, especially from a therapeutic point of view, and under conservative forms of treatment the patients subsequently made uneventful recoveries. This statement should not be interpreted to mean that these disturbances of the reflexes were mere vagaries which did not reflect any definite pathological lesion in the nervous system; rather, that when these abnormalities were present, lesions must have coexisted which were trivial, and could be recovered from, or could be made good by compensatory effort.

Abnormal reflexes, such as an ankle clonus, a Babinski, a Chaddock, etc., were frequently present. Most often these, too, were part of some larger clinical entity and then they were interpreted as indicating some disorganization in the deeper layers of the cortex or in the subcortical areas. Less often an isolated abnormal reflex, usually a Babinski or an ankle clonus, could be elicited, or the abnormality was associated with some change in the normal reflexes as indicated in the previous paragraph. Here, too, the significance of the changes was not apparent in the total clinical picture, especially as a therapeutic indication; and when no other and more definite indications of trouble were present the usual practice found it wiser to regard these most conservatively. A similar explanation is vouchsafed as was given in the previous paragraph. The notes of the following case are given as an illustration:

Hospital No. 155758. An automobile accident resulted in an injury in the right parietal region of a boy of nine years. There was immediate unconsciousness but no vomiting or external bleeding. The important points in the neurological status included: (1) eccentric pupils which dilated and contracted alternately; (2) absent abdominal and normal cremasteric reflexes; (3) absent knee- and ankle-jerks; (4) bilateral Babinski but no ankle clonus; (5) negative fundoscopic examination. The X-ray showed a Y-shaped fracture in the region of the right parietal bone. Consciousness was rapidly regained and thereafter the boy went on and made an uneventful and perfect recovery.

Eye Symptoms.—In 13 of the cases there were abnormalities in the external and internal ocular apparatus; in 3 of these the pupils were unequal; in one the pupils reacted sluggishly; in 2 there was bilateral deviation of the

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eyeballs; in one there was a paralysis of an extrinsic muscle; in 3 nystagmus was present; and in 3 others there was an exophthalmos.

The bilateral deviation of the eyes occurred in patients with fractures in the parietal portions of the skull; the phenomenon apparently has the same significance as it would have in an ordinary case of apoplexy.

Two of the cases of nystagmus occurred in patients who later developed meningitis; the symptom was elicited while the signs of the latter condition were fully developed and undoubtedly was directly due to it. The third was an irregular nystagmus which was present in a patient with a fracture which involved the mastoid and injured the lateral and transverse sinuses; it very probably was related to some injury of the labyrinth. The results of the total injury were such as to make the operation, which was done, unsuccessful and the patient died.

The cases of exophthalmos were all unilateral. In one case the fracture was in the right occipito-temporal region probably extending into the base of the skull; in the second, there was a left temporo-parietal fracture running downwards into the middle cranial fossa; in both of these the eye on the corresponding side showed a distinct though slight exophthalmos. The third patient had a bad crushing fracture of the skull and malar prominence which had pushed the latter upwards and inwards into the head; the deformity was pronounced and with it was an exophthalmos so extreme as to cause the eyeball to protrude from the orbital cavity for almost an inch. Rockey has recently described these injuries of the malar prominence and recommends the elevation of the fractured portion with a tenaculum forceps—a procedure which is comparatively simple.

In 25 of the patients fundoscopic examinations were made. No abnormality could be discovered in 14; included in these were cases which were "neurologically negative," as well as cases with other signs of disturbed neurological function. The remaining 11 had abnormalities in the fundi, and the latter included the following:

1. Distention of the veins. Two of the cases were "neurologically negative"; the third was a case with an injury of the longitudinal sinus.
2. One of the cases showed distention of the veins of both fundi with a number of hemorrhages immediately near the disk. The fracture was in the mastoid and occipital regions of the skull and was associated with injury of the lateral sinus.
3. There was a well-marked blurring of both disk margins in two patients. One was a case otherwise negative from a neurological point of view. The other was a fracture involving the occipital, parietal and temporal bones; death occurred three days after the injury, the immediate cause of death probably being uræmia.
4. Perceptible papillœdema was present in three patients. In one case there was an extensive fracture, the fissures of which ran on the right and left sides of the vault and into the base; in both fundi the veins

were distended, and in the left there was a beginning choking of the disk. The second case had an injury probably localized to the motor area near the longitudinal sinus, as evidenced by spasticity of all four extremities; in both fundi there was a beginning papilloedema; there were other signs of extensive damage to the brain and a fatal issue followed. The third was a fracture in the neighborhood of the right parietal eminence which extended forward and also downward into the mastoid; injury of the lateral and transverse sinuses was present in addition; a distinct swelling of the disks was perceptible about two and one-half hours after the injury was sustained.

5. One case of fracture of the skull resulted in total blindness. The notes of this case are very interesting:

Hospital No. 172240. The history was that ten days before admission to the hospital the patient had fallen and struck the back of his head. The neurological data included: (1) stupor; (2) tenderness of the skull; (3) moderately dilated pupils which did not react to light; (4) palsy of the right upper lid and of the extrinsic muscles of the right eyeball; (5) blindness; the right disk was normal and there was marked blurring of the left; (6) an absent left knee-jerk; (7) a turbid, bloody spinal fluid under increased tension. The X-ray demonstrated a T-shaped fracture through the vertical portion of the frontal bone involving both the right and left sides. A subtemporal decompression was done in the hope of saving the eyesight; the operation was, however, unsuccessful and the patient left the hospital totally blind.

Discussion has centred about the possibility of a papilloedema making so rapid an appearance after injury of the skull and of the intracranial contents; the possibility has even been denied absolutely. Our own experience has been of an affirmative nature; not only do we believe that a papilloedema can occur, but we are accustomed to make use of this phenomenon, whenever it may be present, as an important criterion in the summing up of the total clinical picture, especially for its value as a therapeutic indication.

This experience is not in mathematical accord with that reported by Kearney, who made his observations on Sharpe's cases. Kearney finds some cedematous blurring of the disks in all cases of fracture of the skull, which is present during the first twenty-four hours after the injury, which retrogresses in those whose symptoms improve and disappear, and which grows more marked if signs of intracranial compression become apparent and increase. In our own cases the occurrence of blurring, or of actual swelling of the disks, has been present in a minority of the cases only.

Focal Neurological Symptoms.—Focal neurological symptoms, whenever they could be elicited, naturally made the most conspicuous and impor-

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tant element of the entire clinical picture. They were present in 16 of the patients. In most of these the signs of the focal lesion were immediately apparent on the first examination; in the others the development of the objective findings was more gradual. In one patient focal symptoms developed a fortnight after the accident.

Cranial Nerves.—Involvement of the cranial nerves was present seven times. In two of the cases the orbital nerves were involved; one of these was the case of total blindness (*vide supra*) with which there was associated paralysis of the extrinsic muscles of the eyeball and a palsy of the upper lid. This was a permanent result.

In five other cases the facial nerve was involved. In two of these the facial paralysis formed part of a total hemiplegia. In the other three cases the facial palsy existed alone. In one of the latter there was a fracture of both parietal bones parallel to the coronal suture; the paralysis involved all three branches and was still present when the patient left the hospital. In the second the X-ray showed a fissure in the frontal region; the palsy was present in all three branches and was associated with active knee-jerks and a one-sided ankle clonus. The paralysis persisted until after the patient's discharge from the hospital. The third was the parieto-occipital fracture, described subsequently, which developed a meningitis from which the patient recovered; the palsy was present before the signs of meningitis developed and persisted as a permanent effect. No one of the latter three cases was subjected to operation and except for the local paralysis perfect recoveries were made.

Focal Symptoms in the Extremities.—In two of the patients the symptoms were limited to one upper, and in one other patient to both upper extremities. There was no case of actual paralysis; instead we were fortunate enough to find only irritative phenomena. In one of the cases there was marked rigidity of one entire upper limb with a diminution of all the reflexes; in addition there were signs of a marked increase of intracranial pressure. An exploratory craniotomy showed a fracture extending backwards from the parietal to the occipital bone and downwards into the base, and a large subdural clot with the brain under great tension. The patient died within six hours of the operation. The second of the patients was admitted to the hospital two weeks after an injury in the right occipito-parietal region with the story that two days previously (*i.e.*, ten days after the accident) the patient had passed gradually into a comatose state and had developed twitchings in the left hand and forearm. These were quite marked while the patient was in the hospital and in addition he exhibited disturbances of the normal reflexes, and some abnormal reflexes rather irregularly distributed; the fundi were normal. A right subtemporal decompression was done and directly in the exposed area was a large subdural clot and disorganized brain tissue. Progressive improvement began two days later and, on discharge from the hospital, all the neurological disturbances had disappeared. In the

third patient an injury was sustained in the right occipito-parietal region which resulted in spasticity of both upper extremities with exaggerated reflexes in the upper, and inhibited reflexes in the lower, extremities; a marked Babinski on the right, and a slight bilateral ankle clonus were also present. Operation was done immediately and a flap was turned down in the right subtemporal region extending backwards towards the occiput. A large fissured fracture was present in the parietal bone running downwards into the auditory canal, with some depression, and with tearing of the lateral sinus. The operation did not yield a successful issue.

Signs of cortical irritation were present in a fourth patient and were located in both the upper and lower extremity of the same side. The patient was comatose. There were no external evidences in this case pointing to any definite location as the site of the injury, but there was constant twitching in the left upper and lower extremity. The left side was hypertonic with exaggerated reflexes; the right side was hypotonic with diminished reflexes; a bilateral Babinski could be demonstrated. Some very serious and mortal injury existed here, as was evidenced by the findings, by the general condition of the patient, and by the widely dilated pupils, but, nevertheless, a bilateral craniotomy was done over both motor areas, which showed (1) a fracture of the left vault; (2) rupture of the left middle meningeal artery; (3) subdural and subarachnoid bleeding with brain laceration; and (4) bloody cerebrospinal fluid under great tension. The fatality which followed was to be expected.

Hemiplegia.—There were 4 cases in this series in which the dominant symptom was a hemiplegia. One of these is the case described subsequently under vessel injuries (No. 152653). The notes of the other cases follow:

Hospital No. 188349. The patient, a child of nine years, was struck over the head with a milk bottle six hours before admission to the hospital. He immediately became drowsy and complained of headache. On admission the physical findings were (1) a hæmatoma in the parietal region; (2) exaggerated knee- and ankle-jerks; (3) a right-sided ankle clonus; (4) normal fundi; and (5) bloody spinal fluid. Twenty-four hours later the neurological status included in addition (6) pronounced weakness of the left side of the body; (7) some spasticity of the right lower extremity with a Babinski. A left subtemporal craniotomy was done then which showed increased tension of the intracranial contents; an intact dura; and a large extradural hemorrhage. When the clots were cleared out the brain pulsated well and the dura was therefore not opened. The patient died six hours after operation.

Hospital No. 161336. One hour before admission to the hospital the patient had fallen down an elevator shaft. The physical examination showed (1) a semiconscious patient in marked shock; (2) a large hæmatoma in the right parieto-temporal region; (3) bleeding from the right ear; (4) a complete left hemiplegia; (5) immediate loss of all reflexes which began to return shortly; thereafter the left reflexes were

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all exaggerated, there was a left inexhaustible ankle clonus, and a right-sided exhaustible clonus; (6) signs of compression, the pulse dropping down to 44 beats per minute; (7) distention of the vessels of both fundi with hemorrhages. Operation was done four hours after admission; the depressed fracture ran from the mastoid and temporal bones to the occiput; the dura was plum-colored and there was a perforation of the lateral sinus; extensive hemorrhage was associated with laceration of the brain. A contralateral decompression was done in addition.

Twenty-four hours later there was considerable improvement; motion returned in the left upper extremity. On the next day, however, conditions were much worse; the temperature rose to 107° F. and the patient died.

Hospital No. 154449. The forty-nine-year-old patient fell down stairs for a considerable distance about nine hours previous to his admission to the hospital. One hour afterwards unconsciousness supervened, gradually deepened to coma, and persisted. The pupils were contracted; a left-sided external strabismus was present and the right side of the body was apparently paralyzed; the reflexes were absent. Bilateral subtemporal decompression was immediately done; it disclosed increased tension of the brain on the left side and a moderate sized subdural hemorrhage on the right side. No improvement followed; the patient's general condition remained unchanged for the following three days, and at the end of that time he died.

Longitudinal Sinus Syndrome.—In 1915 Holmes and Sargent described over 70 cases of war injury of the longitudinal sinus in which a characteristic symptomatology was observed. As pointed out by Cushing this syndrome has its counterpart in the traumatic spastic paralysis of childbirth—the so-called Little's disease. Since the communication of Holmes and Sargent additional cases following war injuries have been described by Cathelin and by Cushing. Briefly stated the injuries were gutter or tangential skull wounds, or blows through an intact helmet which resulted in fracture with compression or laceration of the longitudinal sinus or of some of its anastomotic branches in the neighborhood of the motor cortex. Frequently the paracentral lobules and the convolutions bordering the fissure of Rolando showed injuries in addition. Thrombosis of the sinus, or of the large superficial cortical veins emptying into it in the area of involvement, were frequently, though not always, found.

Symptomatically there were two groups of cases, the essential part of both being a spastic paraplegia involving both lower extremities symmetrically or asymmetrically; or the paralysis was more extensive in the order in which the motor centres are grouped in the cortex from the superior margin of the cerebrum downwards towards the fissure of Sylvius, and corresponded with the extent of the brain damage from the vertex of the skull downwards on both sides. The differentiation of the

two groups was made by the presence or absence of a sensory ataxia. This differentiation was emphasized more strongly by Cathelin in 1918.

The essential element of the paralysis is the extreme rigidity. Holmes and Sargent used this point in distinguishing this syndrome from that ordinarily seen with cortical paralyses; in the latter they point out that after a transient stage of rigidity the limbs lie flaccid for a period usually about ten days in length, in which time the reflex irritability is inhibited.

In this syndrome pain and temperature perceptions are unaffected and the tactile sensibility is not perceptibly diminished. The discrimination of compass points and the deep muscular sensibilities—*i.e.*, the recognition of the position and of passive movements of the limbs, and the recognition of the form of objects—can show marked abnormalities. These sensory disturbances were found to be most common when the injury was some distance behind the Rolandic fissure.

The symptoms need not necessarily be permanent and Holmes and Sargent point out that when the thrombosis in the cortical veins is not too extensive, it is possible for a collateral circulation to be established sufficient to cause a gradual disappearance of the symptoms.

In 6 of our cases this syndrome was present. The notes of the cases follow:

CASE I.¹—A sixteen-year-old lad was kicked in the head by a horse. There was a scalp wound one inch behind the fronto-parietal suture near the mid-line. No alarming symptoms were present and the injury was considered a triviality. Four days later a progressive weakness of the right arm and leg began to develop. Two days later the physical examination showed the following: (1) cracked-pot percussion over the parieto-temporal region; (2) slight rigidity of the neck; (3) slight swelling of the veins of both fundi; (4) almost complete paralysis of the right arm and leg with exaggerated reflexes; a bilateral Babinski and ankle clonus and a Kernig were also present; (5) marked spasticity of the right leg; (6) fair power in the left leg; (7) less spasticity of the left than of the right leg with a similar condition of the reflexes; (8) a spinal fluid under moderate pressure which was otherwise negative.

Operation was done on the sixth day after the injury. The craniotomy over the site of the injury disclosed a bone fragment of the comminuted fracture depressed for one-half inch below the surface and lying across the longitudinal sinus; the considerable hemorrhage, which occurred on removal of the fragment, was easily controlled by muscle tissue. There was no dural injury. After proper toilet of the wound, the fragment was replaced and the wound was sutured without drainage. Improvement in the signs and symptoms began twenty-four hours after operation, persisted and became progressive, and, on discharge from the hospital, the patient's neurological status was normal.

¹ Private records of Dr. Elsberg.

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CASE II (Hospital No. 183366).—A flying brick striking the head of this boy of eleven years caused a compound depressed fracture in the midline at approximately the junction of the parietal and occipital bones. The dominant neurological findings included spasticity of both lower extremities with increased, but no abnormal, reflexes. The child was in very bad condition and operation was done mostly to properly cleanse the wound. The fracture was comminuted and markedly depressed and overlay the longitudinal sinus; numerous fissures passed forwards and backwards and across the midline. A small portion of the cortex was exposed through a lacerated dura. One bone fragment was imbedded in the longitudinal sinus; on freeing this a furious hemorrhage occurred which was controlled with difficulty. The child died three hours after the operation.

CASE III (Hospital No. 153545).—The patient, a boy of seven years, was hurt in an automobile accident just prior to his admission to the hospital. An immediate examination showed the following: (1) stupor and marked restlessness; (2) a hæmatoma in the left parietal region; (3) deviation of the eyes to the right; (4) a left complete facial paralysis; (5) marked spasticity of the lower extremities with short jerky movements and with the feet in an equinus position; (6) exaggerated knee-jerks, the right being more marked than the left; (7) abnormal reflexes on both sides—Babinski, Oppenheim, Mendel, etc. Two days later the spasticity had lessened but otherwise there was little change; the stupor continued. Operation was proposed but was refused and the patient was removed from the hospital. An X-ray examination showed a transverse fracture in the parietal portion of the skull, longest on the left side and near the coronal suture.

CASE IV (Hospital No. 179660).—This little girl of six years was thrown from an automobile. There was a swelling over the right mastoid; a second swelling over the occipital protuberance; a third over the left parietal region. The neurological findings included (1) unequal pupils which did not react to light; (2) a beginning papilloedema; (3) right internal rectus palsy; (4) spasticity of all four extremities; (5) absent abdominal reflexes; (6) exaggerated knee-jerks and positive Babinski, Gordon, and Oppenheim reflexes; (7) peculiar athetoid movements of the hands with complete flexion of the hands at the wrists; (8) coma. The temperature was 104° F.; the breathing had Cheyne-Stokes characteristics; compression signs were very marked; and the general condition rapidly became very bad. Just before death the spasticity had disappeared, the reflexes were abolished, and the pupils were unequally dilated.

CASE V (Hospital No. 180991).—The patient, a child of nine years, was struck by an automobile. The neurological status included (1) unconsciousness with Cheyne-Stokes breathing; (2) unequal pupils which did not react to light; (3) marked spasticity of all four extremities; the hands are described as having "peculiar contractures"; (4) hyperactive reflexes. The general condition of the patient was very bad and death occurred four hours after the injury.

CASE VI.²—A boy of eleven years was struck by an automobile on the left side of the head. The immediate findings included (1) stupor; (2) deviation of the eyes to the left with pupils that reacted to light; (3) except for some slight increase of the reflexes on the right side, no abnormality in the upper extremities; (4) lively right abdominal and absent cremasteric reflexes; (5) marked spasticity of the right lower extremity so that the leg is bent with difficulty and the reflexes are not elicitable satisfactorily on account of the spasm; (6) a less spastic condition of the left lower limb with exaggerated reflexes and an ankle clonus; (7) bilateral Babinski; (8) practically negative fundoscopy; (9) a large hæmatoma in the parietal region. From the symptoms it was predicted that the lines of fracture would cross the median line of the skull and the longitudinal sinus and so the X-ray showed the injury.

A week later the symptoms were all much better.

I add the notes of a seventh case which probably belongs with this group.

CASE VII (Hospital No. 177039).—A thirty-three-year-old man fell from a ladder a distance of six feet and landed on his shoulder and side of the head. A period of unconsciousness was followed by improvement in the mental state. The findings included (1) a hæmatoma over the right parietal region; (2) dilated pupils which reacted; (3) irregular nystagmus with lack of coördination of the extrinsic muscles; (4) spasm of the right shoulder; (5) exaggerated knee-jerks and a beginning left ankle clonus. Twenty-four hours later the patient was again deeply unconscious and the findings now included the following: (6) widely and unequally dilated pupils with marked distention of the veins of the fundus and later a definite papilloedema; (7) rigidity of the lower extremities with exaggerated and unequal reflexes. The X-ray showed a fracture running downwards from the parietal eminence towards the mastoid and in a forward direction from the latter.

A bilateral subtemporal decompression was then done. The lateral and transverse sinuses were found lacerated and the bleeding was controlled by packing and muscle tissue. The patient died within an hour of the operation.

This case is included here inasmuch as in all probability there co-existed an injury to the longitudinal sinus which was not demonstrated at operation.

All of our cases in this group had the injury in the general neighborhood of the vertex of the skull and the fractures involved the parietal bones alone, or the parietal and occipital bones near their mutual junction. Two of the fractures were compound. In all, except one, the symptoms were practically immediate. In the exception the symptoms gradually developed over a period of two days and began four days after the injury.

The general symptoms of brain injury were well marked. In two of the patients these indicated such a severe injury as to make any oper-

² Private records of Dr. Elsberg.

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ative interference unjustifiable and these died shortly after admission to the hospital. In four of the patients the degree of stupor or coma precluded the possibility of a complete sensory examination so that we are unable to make any differentiation based on sensory grounds, such as was made by Holmes and Sargent and by Cathelin. Case VI demonstrated how these symptoms might be temporary; in this case improvement in the symptoms and objective findings began several days after the injury. This corresponds with the rather rapid improvement noted in one of Holmes' and Sargent's cases.

There was no thrombosis to be seen in the two cases subjected to operation. There was, however, marked depression of the fragments with compression of the sinus which interfered with the flow of blood, as well as some damage to the adjacent cortex.

Three of the patients in the longitudinal sinus group died, one following, and two without any, operative interference. One patient improved spontaneously; another made a perfect recovery after operation; in the last case the final result is not known because the patient was removed from the hospital against advice. Our mortality was rather high for these patients—about 60 per cent. This is higher than in the results reported by Cushing for the military cases, which was 30.7 per cent. We believe the difference in our cases to be due to the severity of the initial trauma.

COMPLICATIONS

Vessel Injury.—Intracranial hemorrhage as demonstrated at operation was a frequent accompaniment of the fractures in our cases. The source of the bleeding was (1) the meningeal vessels, (2) the contused or lacerated brain, (3) the venous sinuses, or (4) combinations of these sources. Undoubtedly in the remaining unoperated cases more or less hemorrhage was frequently present but its amount was not sufficient to demand any interference or even to call forth any indicative symptoms.

The symptoms, when present, were either those of a general intracranial compression, or indicated a disturbance of function in a localized portion of the brain; in some of the patients there were initial focal symptoms followed more or less quickly by the signs of general compression. In the cases with focal symptoms the diagnosis of hemorrhage was frequently a supposition based on empiric grounds, inasmuch as similar symptoms might very well occur with a localized disorganization of brain tissue. The notes of the two following cases are given as illustrations:

Hospital No. 152653.—A thirty-nine-year-old man fell from his truck and, although he landed on his head, was able to walk to the hospital, where he complained chiefly of headache and dizziness. Shortly thereafter he fainted and went into stupor, and the latter alternated with short periods of consciousness. The essential symp-

toms included a left hemiplegia and the signs of a progressing intracranial compression. The operation which was done within two hours of the injury showed an extensive stellate fracture into the base with depression of the fragments, and a large extradural hemorrhage. The clot was cleaned out and, after the bleeding had stopped spontaneously, the cavity was drained by a gauze strip and the outer wound was sutured. The immediate good effect of the operation persisted and became progressive.

Hospital No. 148405.—In contradistinction to the previous case this patient, a boy of nine years, was brought into the hospital in a stuporous condition with the history of an injury to his head. The dominant symptoms in this case also included the signs of a marked increase of intracranial pressure with a paretic condition of the left side of the face and convulsive seizures in the left upper and lower limbs. The exploratory craniotomy did not disclose any hemorrhage, but a brain exceedingly tense with œdema, indicating that the brain was badly contused. No improvement followed the operation, death following shortly thereafter.

Compression phenomena resulting from œdema more commonly result relatively slowly, and, usually, several days follow before the evidences are fully developed. For this reason it is good practice to carefully watch the variations in the pulse and respiration, and whatever changes may occur in the fundi, for several days after any head injury. Less commonly consecutive to a cerebral trauma œdema occurs very rapidly; a good example of the latter is the acute œdema which occasionally follows operative interference for the removal of brain tumors.

Injuries of the venous sinuses have proven themselves to be complications of extraordinary gravity. The condition was found five times in this series of cases: on two occasions the longitudinal sinus was found torn; in two other cases the lateral sinus was lacerated or perforated by a bone spicule; in another case the lesion was in the lateral and transverse sinuses. In all of these cases, except one, the clinical picture on admission to the hospital was that of an advanced grade of intracranial compression and immediate operation was deemed imperative; in all extensive hemorrhage was found. There was often associated a comminuted and depressed fracture and on exposing the injured area the opening in the sinus was found to be partially, or entirely, occluded by one of the fragments. In several of the cases the sinus injury was not anticipated and on elevating or removing the fragments a profuse hemorrhage flooded the wound. The best way of controlling the bleeding, however profuse it may be, was by applying over the rent a sufficiently large piece of muscle or fascia and holding it in place by pressure with a sponge for a few minutes. Ortali accomplishes the same purpose by making use of a pediculated flap of aponeurosis from the immediate neighborhood. The general principle of both of these procedures was

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first recommended by Horsley many years ago since which time it has been employed very often.

In the exception noted in the last paragraph (*vide* Case I, under "Longitudinal Sinus Syndrome") the immediate symptoms were trivial and alarming symptoms necessitating operation appeared six days later; this was the only case of sinus injury in our series which recovered. All of the remaining cases with this complication terminated fatally within a comparatively few hours after the operation. Injuries of the lateral sinus seem to carry with them a much graver prognosis than those of the longitudinal sinus. Corroboration of this statement is found in the cases of war injuries studied by Velter; in the latter's series there were three cases of lateral sinus injury with two deaths and four cases of longitudinal sinus injury with one death.

Leakage of Cerebrospinal Fluid.—Two important conditions which complicate fracture of the skull are directly associated with compound fractures communicating with the skin, the naso-pharyngeal space, or the middle ear. In two of the cases there was a profuse leakage of cerebrospinal fluid through the external wound. The phenomenon, however, did not lead to any extraordinary symptoms; a meningitis did not arise; and the patients made uneventful recoveries. One of the cases had a compound fracture through the frontal bone. The other had a fracture of the petrous portion of the temporal bone the fissures of which extended through into the middle ear where the drum-head had been torn; the discharge of cerebrospinal fluid continued for eight days, and thereafter the opening in the drum-head closed spontaneously.

Meningitis.—A complicating meningitis was encountered four times. Twice the fracture ran through the frontal bone into the nose by way of the frontal sinuses; once the fracture passed through a suppurating middle ear. In two of these we have bacteriological studies indicating that the responsible organism belonged to the pneumococcus group. In the middle ear case the fracture could not be demonstrated by the X-ray; it was, however, easily seen post-mortem. All of these terminated fatally.

One case of meningitis complicating an occipito-parietal fracture recovered. The notes of this case are as follows:

Hospital No. 154616.—A young woman of twenty-one years, having fallen from a street car, landed on the back of her head. She vomited frequently thereafter, and was very restless, and bled slightly from the nostril. On admission she was conscious, had no paralysis of the limbs but a distinct weakness of all three branches of the left facial nerve; the normal abdominal reflexes were exaggerated on the right side; there was a Babinski, an Oppenheim and a Gordon reflex on the right, and an exhaustible ankle clonus on the left side. The fundi were negative. There was a laceration of the midoccipital region with a large hæmatoma.

Twenty-four hours later there was marked rigidity of the neck with a bilateral Kernig and the patient was irrational. A lumbar puncture showed the spinal fluid to be bloody and under considerable pressure; on subsequent puncture the fluid was yellow. The symptoms continued and on the fifth day the disks showed a distinct papilloedema. Three days later the symptoms began to disappear; thereafter the improvement became progressive; and on discharge from the hospital the facial paralysis was the only abnormality present.

We have been struck by the fact that the two cases of cerebrospinal fluid leakage did not lead to a meningitis. The same immunity to infection seems to be present in other somewhat analogous cases in which a free escape of cerebrospinal fluid takes place. There was one patient with a paravertebral abscess which had been properly incised and drained. Several days later it was noted that cerebrospinal fluid was escaping from the wound. In spite of the fact that the entire environment of the fistula was thoroughly infected, no meningitic symptoms ever developed and the boy made an uneventful recovery. A similar accident occasionally follows operations upon the brain. The post-operative leakage of cerebrospinal fluid may be moderate or profuse and persists for a comparatively long period before the fistula in the scar closes. Infection, however, occurs with extreme rarity.

We have been equally struck by the absence or escape of cerebrospinal fluid in the compound fractures which were complicated by a diffuse meningitis. That the dura is not always torn was demonstrated in some published post-mortem examinations (Schmidt). In these cases contusions of the dura mater with microscopical lacerations, or the traumatic conversion of an area in direct relationship with an infected locality into a *locus minoris resistentiæ*, would furnish a sufficiently plausible mechanism for the occurrence of the meningitis. On the other hand, great numbers of gunshot wounds have been reported (Hartmann, Mueller, Fraser, Sargent and Holmes, Cushing, etc.) in which the dura was found to have been opened widely; and the absence of comment indicates that these were not complicated by the escape of cerebrospinal fluid; some of these later developed meningitis. The explanation of this phenomenon is not quite apparent: possibly there is a reflex inhibition of the flow of cerebrospinal fluid; or the nature of the injury is such as to encourage in some of the patients an extraordinarily rapid agglutination of the pial surfaces surrounding the area of involvement. The last explanation is extremely theoretical inasmuch as in actual practice it is extremely difficult to promote the formation of adhesions of the pia-arachnoid.

Icterus.—An unusual complication occurred in one of the cases of meningitis which followed fracture of the skull: an icteric condition of the skin appeared in a child of nineteen and one-half months with a

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fracture of the frontal bone while the signs of meningitis were at the maximum. The child died three days after the injury was sustained.

TREATMENT³ AND INDICATIONS FOR TREATMENT

Compound Fractures.—It has never been considered an absolute rule to make use of this complication as an imperative indication or as a convenient excuse for operating upon the fracture itself. When no other compelling symptoms or objective findings were present, the outer wound was cleansed in the proper surgical manner and was sutured, and most often healing took place by primary union; the fracture itself was not disturbed. Infection of the bone very rarely took place; a rigidly conservative treatment was then practiced and always healing took place after a small superficial scale of bone had sequestered out. In a general way this plan of treating the local wound, which was practiced even before the war, corresponds very well with the local treatment of the war wounds, the so-called "débridement," so widely emphasized by the military medical men.

Craniotomies.—According to the symptoms exhibited the patients who were operated upon were subjected to a unilateral or bilateral subtemporal decompression, to a unilateral or bilateral exploratory craniotomy, or to an exploratory craniotomy plus a contralateral subtemporal decompression.

The method of making the subtemporal decompression followed that described by Cushing; the essential steps included splitting of the temporal fascia and muscles in the direction of the fibres, the subperiosteal removal of that portion of the skull lying directly underneath, and the opening of the dura mater. We do not consider it to be sufficient to remove a small segment of the skull; the minimum that we recognize as a decompressive opening is a fenestra 5 by 6 cm. in diameter and frequently we make them much larger.

A number of the craniotomies have been flap operations. They were made over the area suspected and the bone-flap turned down was sufficiently large to enable one to work with ease; as a general rule, the bone-flap was replaced at the close of the operation and the outer wound was sutured without drainage. Of necessity these were mostly exploratory operations. In other patients the procedure was carried out primarily as a flap operation; during the manipulations the advantageousness of a decompression was recognized and at the close of the operation the bone-flap was removed in order to accomplish this desideratum. This was only advisable when the flap had been fashioned in the temporal regions; otherwise it seemed wiser to do a contralateral decompression in the usually approved manner.

³The various operations in this series of patients were performed by Doctors Elsberg, Taylor, Brickner, and Wilensky. Case No. 172240 was operated upon by Doctor Buerger.

In the remaining operated patients operation was done for depressions of various kinds. In some it was simply to insert a hook and elevate the depressed fragments; in others it was necessary to use more energetic measures, and a very good way was to cut a fissure directly through the entire depressed area with a bone-cutting forceps and then to elevate each half separately. In any case the procedure followed general surgical principles.

When the dura was found torn the opening was utilized, when conditions called for it, for exploratory purposes. At the conclusion of whatever manipulations were found necessary, the laceration in the dura was repaired by suture. If the necessary "débridement" resulted in a dural defect the latter was made good by a plastic operation or by the use of cargile membrane. An intact dura was never incised except in the presence of evidence of subdural injury and hemorrhage, or when a decompressive effect was desirable. Drainage through the dura was never employed.

Lumbar Puncture.—In no one of the cases in which lumbar puncture has been practised has it seemed to give any added information which would be of value in the comprehension of the clinical picture; nor did it subserve any useful function from a therapeutic point of view. Certainly when the intracranial pressure was very high it had no decompressive effect and other measures were necessary to obtain efficient diminution of the compression.

In studying cases of crushed or fractured skull following war injuries, LeRiche found that the cerebrospinal fluid was as often clear as sanguineous and that he could never draw any certain conclusions, inasmuch as about 16 per cent. of the pure scalp wounds were associated with colored spinal fluids. Nor could he extract any useful information from studying the pressure of the spinal fluid. Chemical and cytological examinations of the fluid also yielded no pertinent facts. LeRiche found, however, that repeated lumbar punctures exhibited good therapeutic effects in these war wounds. Similar good effects were noted by Alhaique. Albert has also noted such good effects, and, in addition, lumbar puncture has proved, for him, an efficient method of diagnosis in doubtful cases.

The experiences of Cushing and of Gray, as regards the therapeutic effect of lumbar puncture, are more in conformity with our own. Cushing regards it as a palliative measure which affords but a very short period of relief. Gray has found the procedure useful sometimes in relieving the general evidences of pressure, but just as often the lumbar puncture fails to have any effect. Possibly our own experience has been due to the fact that we have not been very persistent with this form of therapy, for the reason that in those cases in which it might have been applicable it seemed much better judgment to us to operate and procure an immediate, an efficient, and a permanent relief of the compression, rather than be content with a palliative measure which, under the best circum-

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stances, would yield only a temporary relief, and which might fail at a critical moment.

Weed and his co-workers have pointed out that the withdrawal of cerebrospinal fluid through a lumbar puncture can, in the presence of some infective focus in the body, be followed by a meningitis. These conclusions were based on grounds entirely experimental, the essentials of which include an artificially induced bacteraemia followed by a lumbar puncture. Lumbar puncture has been done numberless times for war fractures of the skull with and without injury of the intracranial contents and in the presence of infection, and up to the present no case has been reported in which the indicated accident has taken place. However, in contradistinction to these traumatic cases, Wegforth and Latham, in writing of their experiences during the recent epidemic, report five personal cases and refer to others in the literature in which the release of cerebrospinal fluid by lumbar puncture in patients with bacteraemias, was followed by meningitis. The five personal cases reported occurred in meningococcus infections. It is well, therefore, for one to be on the lookout for such a contingency.

RESULTS

Immediate Results.—Of the 72 cases in the series 22 patients died, making a total mortality of 31 per cent. Eighteen of the patients were operated upon and of these 6 died—a mortality for the operated cases of over 48 per cent. Of the total number of fatal cases 36 per cent. were operated upon. Of the remaining cases, which were treated conservatively, 14 died—a mortality of almost 27 per cent. Subtemporal decompression was done 8 times; 5 of these died, 2 recovered completely, 1 was unimproved. Craniotomy alone was done 7 times; 2 of these made recoveries and the remainder died. Craniotomy with contralateral decompression was done in 3 cases with 2 deaths.

In comparison with these the statistics published by Mixter of Boston showed the following results: General mortality, 54.1 per cent.; operative mortality, 43.4 per cent.; mortality after expectant treatment, 58.3 per cent. In our series there were much better results following the conservative plan of treatment; and it is rather curious and very interesting to note how closely the mortality figures of the operated cases approached one another in the two series of cases.

The most important reason for the high mortality of the cases operated upon is probably the nature of the original injury, or some extraordinary condition complicating the primary lesion. We do not believe that operation, done skilfully and under good conditions, adds anything to the risk, or the final result. A glance through the case reports of this communication will corroborate this statement.

In summing up our results from the point of view of the neurologist

in so far as they may have bearings on the indications in any future case, it seems:

1. That conservative and expectant methods of treatment, whenever they can be safely employed, yield the best results. We are unalterably opposed to operating indiscriminately upon every case of fracture of the skull. It seemed to us that as the cases presented themselves for treatment they naturally fell into one of three groups: (a) A large group the members of which always recovered spontaneously; (b) a smaller group the individuals of which were almost certain to die with or without operative treatment; (c) a very small group in which the individuals presented such border-line evidence of intracranial damage as to make a policy of watchful expectancy advisable, but for whom we were constantly in readiness to operate at a moment's notice; the final outcome in these cases was always doubtful.

2. Operation is imperative in every case showing the signs of an advancing intracranial pressure. Operation should be done in the early stages before there is evidence of medullary involvement.

3. Irritative or paralytic focal symptoms pointing to pressure upon or disorganization of definite cortical areas are the next most important indications for operative interference. Isolated or irregular disturbances of neurological function can be discarded and for these conservative forms of treatment will yield superior results; seemingly these abnormalities have no important therapeutic bearing in the total clinical picture.

Late Results.—It has been possible to obtain reports of the late results in 13 of the patients. The periods of time which have elapsed since discharge from the hospital average up to two years. Of these 13 patients 3 were subjected to operation and the remaining 10 made spontaneous immediate recoveries.

Of the unoperated cases two are perfectly well and there are no signs or symptoms pointing to any neurological disturbance. Three patients have generalized or localized headaches, and in two others the headache is associated with dizziness; one patient has spells of dizziness alone. These symptoms are not severe, make their appearance at rather infrequent intervals in most of the patients, and do not incapacitate the patients in any way for their routine work. One patient vomits occasionally; it is difficult to connect the symptom with any neurological lesion, and it is equally possible that it is the manifestation of some temporary gastro-intestinal disturbance.

At the present writing there is evidence in two cases of permanent focal neurological abnormalities. The first patient is a boy of eight years in whom one of the fissures of a stellate fracture in the right parieto-temporal region extended into the external auditory meatus. During the stay of the patient in the hospital the neurological status was normal and a similar condition persisted at the time of discharge. At the time

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of the last report—two years after the injury—hearing in the right ear is diminished approximately one-half. There is no history of there ever having been any disease in the middle ear. In a discussion of the ear complications of fracture of the skull, Fraser, quoting Brun, notes that disturbances of hearing follow in 14 per cent. of all skull injuries and in 24 per cent. of basal fractures.

The second is the hospital patient No. 172240, in whom a frontal bone fracture was associated with blindness; although no further report is available we assume that the blindness is a permanent defect.

Epilepsy, either general or of the Jacksonian type, has not developed in any of the patients we have been able to follow.

The three patients who were subjected to operations are, up to the present writing—between one and one and one-half years—perfectly well and their neurological status is normal. One of these is the hospital patient No. 186858 described above; the second is the first case of those described under the "Longitudinal Sinus Syndrome." The third is a young child of fourteen months who had sustained a fracture at the inferior angle of the parieto-occipital junction. The operative findings included a depressed fracture, an epidural clot, laceration of the dura, and traumatized brain tissue; the bone depression was cut away, leaving an exposed area the size of a silver dollar; uneventful healing followed.

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GUNSHOT FRACTURES OF THE HUMERUS TREATED BY SUSPENSION AND TRACTION

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A STUDY of the results obtained by different methods in the treatment of war wounds is necessarily obscured because of such variables as extent of the original injury and delay in hospitalization, but more especially because it is impossible to carry out the treatment from start to finish in any single hospital. With these difficulties in mind, it is the purpose of this paper to review the cases of gunshot wounds of the humerus treated in the service of Colonel Joseph A. Blake at American Red Cross Military Hospital No. 2, where the method of suspension and traction as developed by Colonel Blake has been carried out.

The hospital was opened May 2, 1917, as an institution for French wounded, and although militarized November 1, 1917, did not receive American wounded in large numbers until June, 1918. During this period its status was that of a base hospital receiving patients from several days up to several weeks after wounding, and evacuating them in a leisurely manner. During the summer and early fall of 1918, it served both as evacuation and base hospital; from then on until closing, January 31, 1919, it resumed its original character of base hospital. The result of the intensified demands of the summer months was the reception of a large number of early cases who had had long transportation without previous treatment; and also enforced evacuation of many cases who would have been otherwise retained.

Under these circumstances, our statistics have to bear, in part, the brunt of evacuation hospital problems such as gas gangrene, and also base hospital problems such as prolonged sequestration and delayed union. French patients continued to be received in small numbers up to the closing of the hospital, but almost always after previous hospitalization, so that a comparison between the two series shows, for instance, an absence among the French of those grave infections which do not pass the evacuation hospitals.

It has been the policy to retain cases of fractured humerus if possible until union was established. If circumstances do not permit this, we have preferred to forward at once, those of them who are in good condition, to the place where they will receive their definitive treatment. This series therefore contains a number of early cases in good condition who remained only a day or two. It also contains a considerable proportion of cases who were evacuated as soon as, or shortly after, union had become established. On the other hand, there are some who were received after the average period required for union.

Gunshot fractures present not only the problem of the fracture, but also that of the wound, which means infection in a considerable proportion of

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cases. We believe that suspension and traction, without a fixed splint, meets both problems better than any other method for the treatment of compound fractures of the humerus.

The method has already been described in the publications of Colonel Jos. A. Blake^{1, 2, 3} and Major Kenneth Bulkley,² so that a brief résumé only will be given (Fig. 1).



FIG. 1.—Compound fracture of humerus suspended in abduction. (Photograph of colored drawing made by Sgt. 1st-cl. Owens, M.D.)

The arm is supported in a sling from an overhead pulley. The forearm is suspended by glued bands in the same manner, but with attachment further away from the body, as its centre is in a plane outside that of the arm, when the member is abducted. Traction is obtained by bands glued to the arm, the wound permitting, more often by a band encircling the arm just above the elbow, and attached by a pulley to the frame, or an abduction

board placed under the mattress. In this way it is always possible to maintain the fragments in alignment by altering the angle of abduction and varying the relative suspension weights on the arm and forearm. In the few cases where abduction and traction alone do not correct a lateral deformity, lateral traction in opposite directions on the two fragments can easily be added.

The disadvantage urged against this method is that it confines the patient to bed. In the case of infected compound fractures of the humerus, this is desirable. Those who might otherwise be in an ambulant apparatus, we believe are more than compensated by an ultimate shortening of the period of treatment. Especially in the case of soldiers, who are totally useless from the point of view of service, while they are in hospital, the longer confinement to bed has no importance whatsoever and in fact is indicated, provided they can be thereby fitted more quickly for duty.

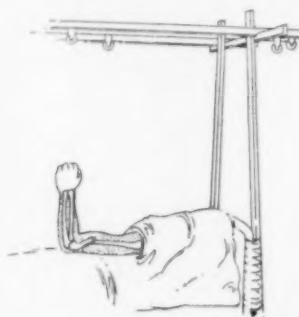


FIG. 2.—Fractured arm as admitted. (Figs. 2-4 are schematic drawings made from X-ray plates of Sgt. Dustin by Sgt. 1st-cl. Owens, M.D., to demonstrate reduction of a fractured humerus and maintenance in position in the Blake suspension apparatus.)

The advantages of suspension and traction are:

1. Maintenance of favorable position from the point of view of circulation and drainage.
2. Ease and simplicity of dressings.
3. Comfort of the patient.
4. Control and maintenance of reduction.
5. Earlier restoration of function.

With regard to the first three points, it is to be noted that this method was first used in arm cases by Colonel Blake⁴ on account of its advantages in the handling of cedema and infection.

Control of the Fracture.—Is best illustrated by the accompanying photographs of X-ray plates made at the bedside, showing deformities and their correction. A portable X-ray machine is indispensable to the proper treatment (Figs. 2-17).

Earlier restoration of function could only be proved with mathematical precision by a comparative series of cases treated from start to finish under one direction. Those, however, who are experienced in the Blake method of suspension and traction, and who have seen how rapidly patients may regain the use of their arms, are convinced that it allows the minimum of joint

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and muscle adhesions to form while maintaining a maximum of muscular power and nutrition. While in the apparatus, patients are taught to exercise both elbow and shoulder even before union has begun (Fig. 18). The wrist and hand are always freely movable. Massage is carried on from the start. The patients are kept suspended until union is sufficiently firm to allow them up without support. Once up, we have come to feel that in the ordinary case they should not even be allowed a sling, so that complete mobilization of joints may be carried on as rapidly as possible.

The first treatment of the man with a gunshot fracture of the humerus, after he arrives in hospital, is that of the wound. Almost all shell wounds and some bullet wounds require operative interference. Fragments of bone absolutely detached are removed, but where there is a reasonable prospect of

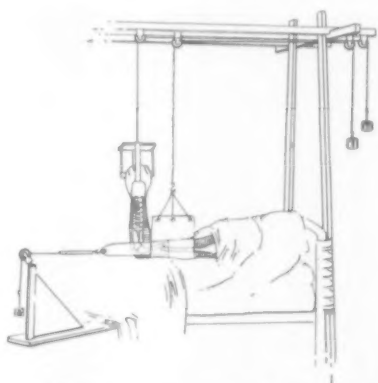


FIG. 3.—Arm has been suspended, position of fragments is improved but there is insufficient traction and too heavy weight on arm.

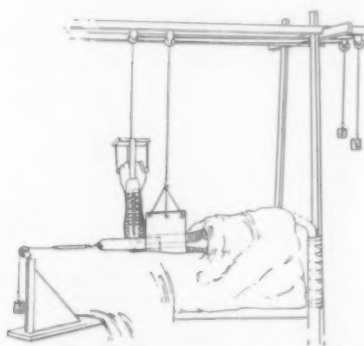


FIG. 4.—Traction has been increased from two to three pounds and the weight on arm reduced from three to two. Weight on forearm in this case was left the same.

viability, they should be left. Delayed union and pseudarthrosis are the sequelæ of injudiciously radical operating.

After the preliminary treatment, the earlier the suspension the better. We believe, however, that it is worth while to apply it to patients received late, provided union has not become firm, and even sometimes with union in the presence of severe or persistent infections.

In the later stages of treatment sequestration should be watched for and sequestra removed as soon as separated, not only because they maintain suppuration⁵ and inhibit union, but because of their liability to become enclosed in cavities of new bone with outlets too narrow to permit of their extrusion. Should this so-called "dice box" condition arise, a free laying open of the cavity with consequent weakening of the bone is necessary to effect a cure.

The number of cases in the records of the hospital, on which this study is based, is 152, of which 105 were Americans and 47 French. Of these, 26 were under observation for so short a time that they add little to the series, and in a number of other cases the records are so scant that their value is not great.

Missile.—The question of missile has considerable importance because of the greater liability to infection of shell wounds. Many bullet wounds can be treated as simple fractures. It is well known that they often unite more rapidly than the ordinary simple fracture, because of the greater stimulation to repair that such comminuted fractures receive, as opposed to the transverse or oblique fracture of civilian life. In this series shell wounds were somewhat more common than bullet wounds.

Wounds were quite evenly divided between the right and left arms.

Type.—The great majority of gunshot fractures are comminuted. The amount of bone injury varies from extensive loss of substance, precluding any hope of union, to trifling wounds of bone (incomplete fractures). In

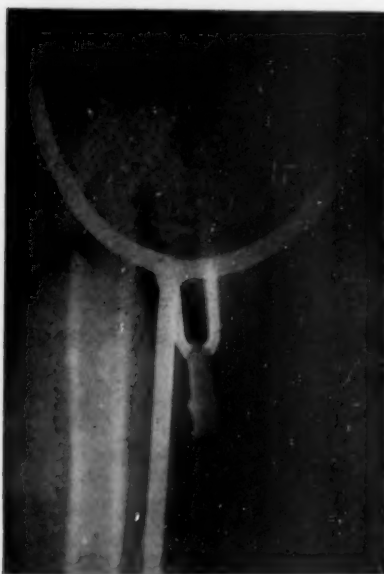


FIG. 5.—Fracture of upper half of humerus as admitted in Jones traction splint. There is insufficient abduction (X-ray of Pvt. Whitford).



FIG. 6.—Same arm as Fig. 5 after suspension (X-ray of Pvt. Whitford).

between are all gradations of injury and destruction, upon the extent of which depends the outlook as to repair and restoration of function.

Location.—Fractures of the lower end of the humerus united a little more rapidly. Where there is joint involvement, the problem depends primarily on the presence or absence of infection.

Infection.—Infection plays an important part in gunshot fractures of the humerus, contributing almost all of the mortality as seen in hospital; and a considerable share of the morbidity, by prolonging the period of repair and disuse and increasing the amount of scar tissue. It may be divided into two main groups, the early due to the gas-forming organisms, and the late due to pyogenic organisms of which the streptococcus overshadows all others in importance.

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The early gas bacillus infections, being infections of muscular tissue, have no direct relation to bone injury, except inasmuch as bone injuries are usually associated with more extensive involvement and laceration of soft parts. Among the 105 Americans of this series, there were seen here seven cases of gas gangrene with one fatality. Among the French there were no cases, explainable undoubtedly by the fact that the latter were not ordinarily received directly from the line.

The streptococcus is largely responsible for the later serious infections and has taken a heavy toll of lives of wounded men. Compound fractures offer ideal soil for it to develop and hang on. On the whole, one is surprised, however, at the comparatively small amount of sepsis in gunshot

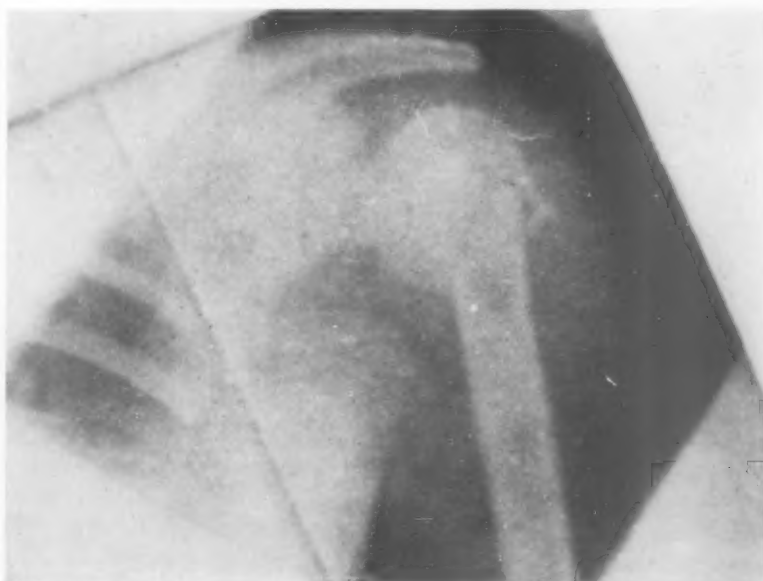


FIG. 7.—Soldat Raymond. Compound fracture of surgical neck of humerus. Head is abducted, shaft is not.

wounds of the humerus in comparison with those of the femur. It is due to the smaller size of the bone and the scantier covering of soft parts of the arm. Judicious and careful early operative treatment will avoid many serious streptococcus as well as gas infections, but in the case of the former one is bound to conclude that dressing infections also contribute their share. It seems that the importance of skilful and painstaking aseptic dressings is not sufficiently recognized. There were two fatalities, both Americans, from streptococcus sepsis.

There were five cases of positive streptococcus bacteraemia, again all Americans, four times hæmolyticus, once non-hæmolyticus. Two of those with hæmolyticus infections died. The rest recovered. These five cases represented the severest types of wounds: two had large loss of substance,

and in two there was either shoulder or elbow-joint involvement. Four out of five came to amputation.

Other infectious complications were erysipelas (2 cases) and phlebitis (1 case). One moderately septic patient was recorded as having pulmonary infarcts.

Primary and Secondary Suture of Wounds.—The immediate or early conversion of a compound into a simple fracture represents an ideal, the attainment of which would mean tremendous curtailment of infection. Our experience in fractures, however, has led us to be very conservative about attempting these procedures. Only five were made in the whole series. Of these, one secondary suture was entirely successful, and in at least two others, one delayed primary and one secondary suture, there was a gain.

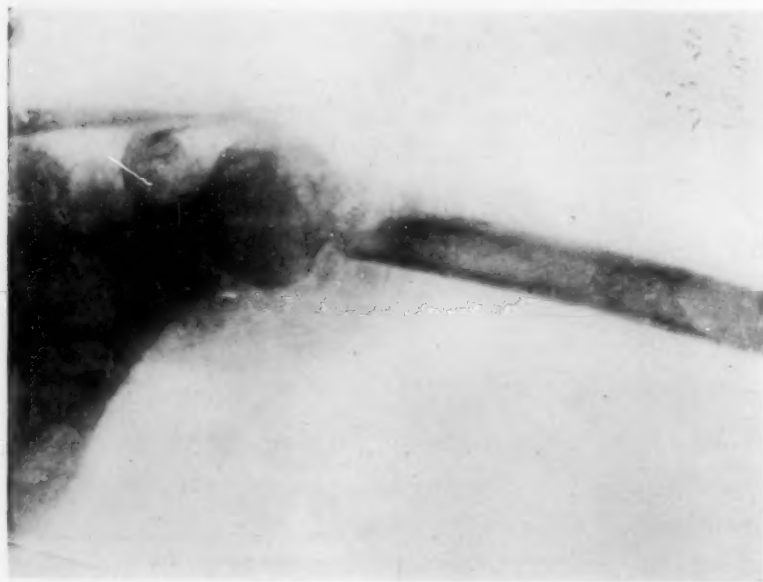


FIG. 8.—Same case as Fig. 7, suspended in wide abduction.

Secondary hemorrhage occurred three times in American patients. All three were very septic.

Joint Fractures.—When a joint cavity is connected with a suppurating compound fracture it offers ideal conditions for sepsis, unless properly drained, including removal of loose bone fragments, because it becomes a bag of pus, continually reinfected from the bone, without proper outlet.

The head of the humerus when hit often suffers tremendous comminution, and the result is that resection, more often than not, offers the only means of drainage. In cases where the fracture only involves the joint by a fissure or fragment, this will not be the case. Uninfected cases not infrequently heal kindly.

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We have had fifteen cases involving the shoulder joint, of which nine came to resection more or less complete. Of the other six, three were wounds of bone; the fourth a fracture of the surgical neck involving the joint but slightly, and the remaining two, uninfected bullet wounds. Resected shoulder cases should be maintained in wide abduction, so that, if union takes place



FIG. 9.—Pvt. Rhyne. Drawing from X-ray. Compound fracture of upper third of humerus. Fracture as admitted, showing typical abduction of upper fragment.

between the end of the humerus and the scapula, abduction by means of the shoulder girdle will be possible. As union in these resected cases occurs only after several months, we have, not infrequently, after the wound has quieted down, gotten the patient up in some type of wide abduction splint. However, some of those in our series have been maintained in suspension with advantage until union has set in.

There were seven elbow-joint wounds of which one only was resected. A second who later came to amputation would probably have done better

if resected in the first place. Of the remaining five, two, wounded by bullets, were uninfected.

Union.—The time of beginning union and consolidation is very important from the point of view of comparison of results of different methods of treatment, as well as that of the cure of the patient. There are difficulties, however, in the way of making this determination. In the first place, many



FIG. 10.—Same case as Fig. 9. Drawing from X-ray. Arm in suspension in proper alignment.

gunshot fractures, on account of the extensive bone destruction, whether with or without loss of continuity, cannot unite until after a prolonged process of repair, sometimes not at all. It is manifestly unfair to include such cases in an enquiry as to the average time of union. In the second place, if all observations were made by surgeons experienced in the treatment of fractures and under the circumstances of a steady but not undue supply of cases, the

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data would not only be more complete than was possible under the conditions of war surgery as they have had to be met here, but would undoubtedly show earlier results, as the time of union could be more carefully observed. In compiling the following figures, cases of delayed union, over three months, have been omitted, as well as cases received here six weeks or more after wounding. Other cases have had to be omitted because of the absence of



FIG. 11.—Pvt. Hobday. Drawing from X-ray. Arm suspended in much abduction.

notes on their records. It has also seemed wiser to keep separate the American and French figures, because the Americans were received earlier and presented a larger proportion of bullet wounds.

Of the 15 Americans in whose histories it was recorded, the average date of beginning union was 24 days. Of these the three earliest were 15, 17 and 19 days respectively; two-thirds of these were bullet wounds.

Of 11 French cases, beginning union as noted averaged 29 days; of these less than half were bullet wounds.

More records contained data as to the time of consolidation or firm union. By the former is meant a union so solid that no further supporting appliance is necessary. Whether those notations as to firm union always implied definite consolidation is not clear, but on account of simplicity it is wiser to group the two together. In many instances on account of incompleteness

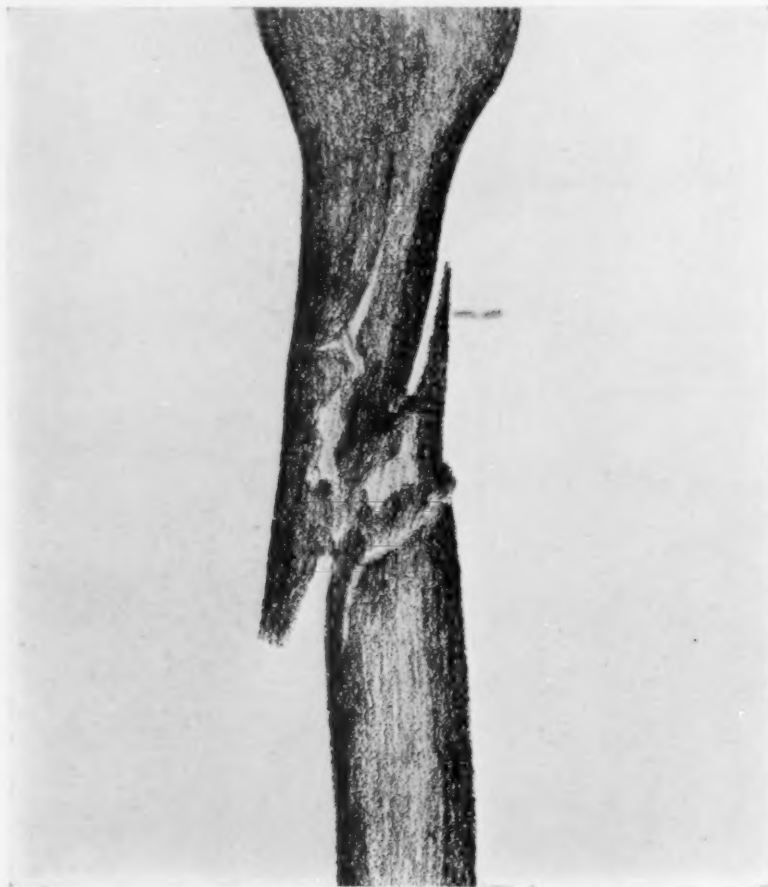


FIG. 12.—Same case as Fig. 11. Drawing from X-ray. Abduction lessened but not sufficiently.

of records the time of removal from the frame has had to be used as that of consolidation, although patients ordinarily are kept suspended for some days after consolidation is thought to be established.

Of 26 American cases admitted early in the course of treatment, the average date of consolidation or firm union was 40 days. Of these, 8 were 5 weeks or under. It is interesting to note that of these cases the bullet wounds averaged 37 days as opposed to 44 for the shell wounds.

Of 21 French cases the average date was 51 days.

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The earliest case recorded was a Frenchman consolidated on the 23rd day. He had a bullet wound of the lower third of the humerus which remained uninfected and did not require operative interference. This man regained function with great rapidity (see Fig. 19).

Another point of view from which the time of consolidation may be



FIG. 13.—Same case as Figs. 11 and 12. Drawing from X-ray. Final position obtained and maintained. See Figs. 31 and 32.

studied is that by periods. Grouping both American and French cases together, the figures are 21st—30th day: 5; 31st—40th day: 17; 41st—50th day: 15; 51st—60th day: 8; third month (61st to 90th day): 5; fourth month: none; after the fourth month, there were 4 cases.

Intimately bound up with the subject of time of consolidation is that of position in which consolidation has taken place; in other words, anatomical

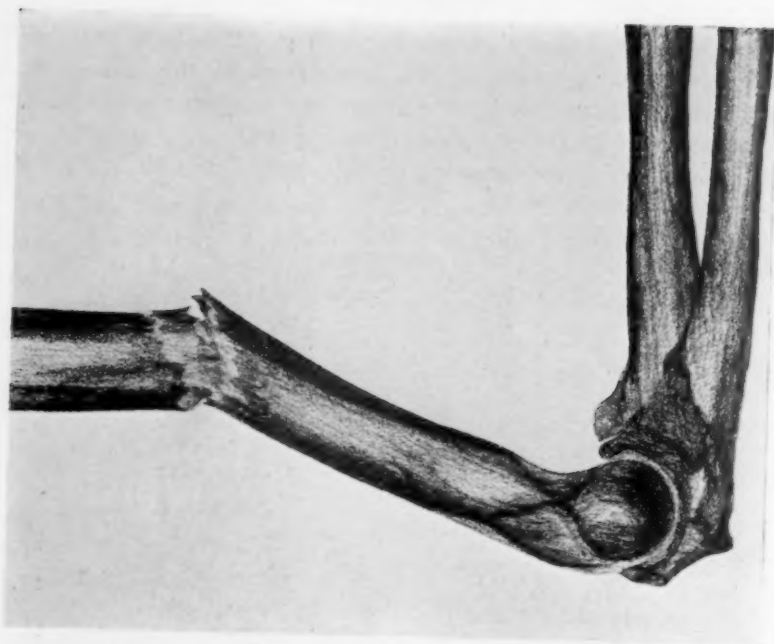


FIG. 14.—Soldat Mignaton. Drawing from X-ray. Simple fracture of humerus. Anterior bowing of arm due to incorrect adjustment of suspension weights.

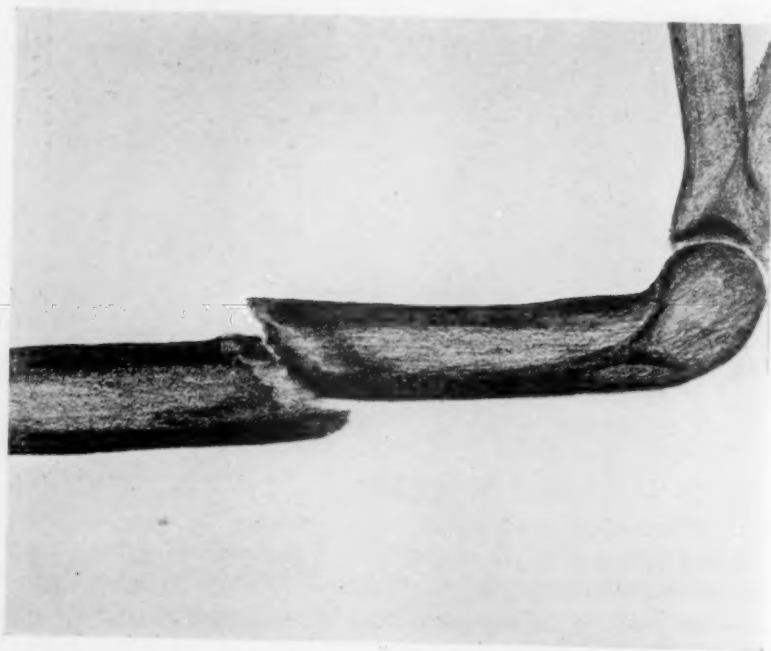


FIG. 15.—Same as Fig. 14. Drawing from X-ray. Arm after increasing weight on forearm and lessening that on arm.

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result. In general the better the anatomical result, the better the functional result.

In this series there was but one case in which consolidation took place in such position that the arm was purposely refractured. With few exceptions, a good anatomical result has been noted, occasionally the final X-ray has shown a slight bowing which is usually hardly apparent clinically. The only convincing demonstrations of results are the X-ray pictures (see Figs. 6, 10, 13, 15, 17, 19-24).

Where a good anatomical result is not obtained by the method of suspension and traction, it must usually be blamed on the surgeon, not the method. As has already been shown, the position of the fragments can be controlled with accuracy. Until union has taken place, however, this position requires repeated checking, clinically and radiographically. This constant watchfulness is a point which an inexperienced surgeon is likely to forget.

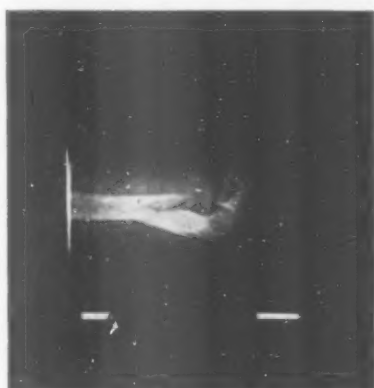


FIG. 16.—Pvt. Gerristead. Compound fracture of lower third of humerus. Showing insufficient weight on the forearm.



FIG. 17.—Same case as Fig. 16. Arm after adjustment of suspension weights. See Fig. 34.

Sequestrectomy.—Seventeen American and 11 French patients came to sequestrectomy, at periods varying from the thirty-eighth to the one hundred and twenty-ninth day for the first intervention. Several of these had to have more than one intervention. This does not represent, especially among the Americans, the proportion of cases which require sequestrectomy, as a considerable percentage were evacuated as soon as union was established. Stereoscopic X-ray pictures give invaluable aid to clinical observation in determining the separation of sequestra (see Figs. 28 and 29). The operative procedure should be done under direct observation which means free incisions. Attempts to separate necrosed ends before there is a line of demarcation usually results in further damaging of living bone, and should not be attempted. On the other hand, separated fragments should be removed at the earliest possible occasion, for reasons already described. It is clear in several of our cases that procrastination has delayed union, and by

prolonging infection and disuse has rendered the problem of restoring function more difficult.

The operation of sequestrectomy is not without risk, first of stirring up a sharp reinfection, which may prove to be a real danger to the patient; and second, of refracturing the bone. The latter cannot always be avoided and is not a grave accident, but causes an unfortunate delay to functional restoration.



FIG. 18.—Pvt. Semfield. F. C. C. left humerus. Superimposed photograph to show mobilization of elbow.

It is not surprising to note that shell wounds were more than three times as numerous as bullet wounds among these cases.

The relation of primary operative interference to late sequestration is a subject in itself, which would require very detailed records to elucidate; these we do not possess, as the majority of the cases did not receive their primary treatment here.

Nerve Injuries.—Nerve injuries occur not infrequently in simple frac-

GUNSHOT FRACTURES OF THE HUMERUS



FIG. 19.—Soldat Verdet. F. C. C. humerus. Very rapid consolidation and return of function.



FIG. 20.—Sgt. Baldwin. F. C. C. humerus. Taken about two and one-half months after wounding, when on military police duty in Paris.



FIG. 21.—Pvt. Finazzo. F. C. C. humerus. See Fig. 35.



FIG. 22.—Pvt. Moulton. F. C. C. humerus. See Fig. 36.

tures of the humerus and more often in gunshot fractures. When one considers the numerous large nerve trunks which pass along the arm it is surprising that they escape as often as they do. Our records show a proportion of one nerve injury in every five gunshot fractures of the humerus, among the American patients, and one in three and one-half among the French patients. The musculo-spiral is the sufferer in the great majority of cases. The lesion varies from slight contusion to complete severance of the nerve.

Twenty-nine patients are recorded as having 31 nerve injuries, not all of them complete. They were distributed as follows: musculospiral, 25; ulnar,



FIG. 23.—Pvt. Wayner. P. C. C. surgical neck of humerus.

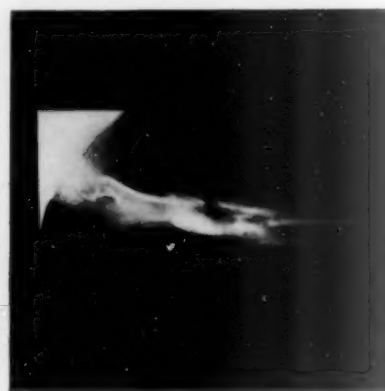


FIG. 24.—Pvt. Andrews. P. C. C. humerus.

3; median, 1; musculo-cutaneous, 1; brachial plexus, 1. Of these five cleared up entirely in a few weeks. Six of our French cases with musculo-spiral paralysis were operated on here for the nerve condition, the earliest on the 111th day. In half of these, the trunk was found severed. The cases were not retained long enough to determine the results. The only observation which one may draw from these cases is that the risk of infection is present for a surprisingly long time in old bone wounds.

Refractures.—Among this series there were 6 refractures in 5 cases. The time varied from the fifty-third to the one hundred and fifty-second day; operative interferences (ordinarily sequestrectomies) were the cause four times and falls twice. Union usually takes place very rapidly in these refractures, because callus is already present. In one case, some union was reported one week after the accident. The others, as far as noted, required nineteen, twenty, twenty-three and forty-three days respectively.

In discussing the time of union, one important result of treatment has been considered. Our patients, unfortunately from the point of view of studying end results, have been discharged from here ordinarily before the rapidity and completeness of restoration of function could be determined.

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From their progress, however, it has been possible to estimate pretty well in many cases whether they would or would not have any permanent disability. Toward the end of our service also evacuation became infrequent, and we were able to observe a group of cases, then in the hospital, until their function was practically restored. Finally we have seen two or three of our old cases since their return to duty. It is my purpose, therefore, to summarize as far as possible the outcome under the following headings: (1) Deaths; (2) Amputations; (3) Fractures Involving Joints (exclusive of 1 and 2); (4) Fractures of the Shaft (exclusive of 1 and 2).

1. *Deaths.*—In the 105 Americans, there were three deaths, approximately 3 per cent., already mentioned under the heading of infections. One was of gas gangrene on the eleventh day; two of sepsis on the twenty-first and thirty-fifth days respectively. Among the French, for reasons already

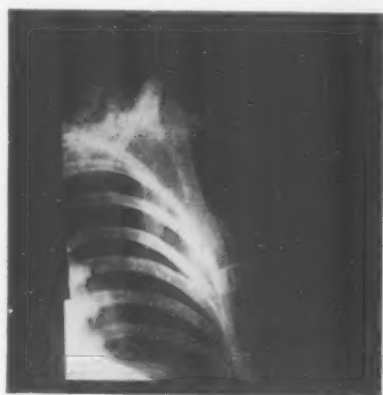


FIG. 25.—Pvt. O'Connor. F. C. C. head of humerus and glenoid. Resection of head of humerus. Union between humerus and scapula. Suspended in wide abduction until subsidence of infection and stiffening of shoulder, then gotten up in aeroplane splint. See Figs. 26 and 27.

suggested, there were no grave general infections, although two died of extraneous causes: one man from abscess of the lung from a wound received at the same time as that of his arm, the second from influenza.

2. *Amputations.*—There were 11 amputations among the American patients, of which 2 before admission; this represents 10 per cent. of the series: 5 were done for gas gangrene, 2 others not stated—probably for gas gangrene, and 4 for septic infections. At least 3 of the cases were associated with large loss of bone substance.

Among the French there were no amputations done.

3. *Fractures Involving Joints.*—As already stated, a more or less complete resection is often necessary when the head of the humerus is fractured. The progress of these cases is very slow and they often require repeated sequestrectomies. They are probably destined to a considerable permanent degree of crippling.⁶

Of the nine resected cases three were evacuated with union between the

humerus and the scapula. The average time required for union in these three cases was 130 days. At least one was evacuated with the prospect



FIG. 26.—Same case as Fig. 25. Shows flattening of shoulder and shortening of arm (one hundred and sixty-first day).

of a flail-joint. The remainder were not under observation long enough to judge of the anatomical outcome. The extent of function which the arm will recover in these cases cannot be determined until a much later period (Figs. 25-27).

GUNSHOT FRACTURES OF THE HUMERUS

The one patient on whom elbow-joint resection was done did excellently while here, but the final outcome will remain in doubt for a long period.

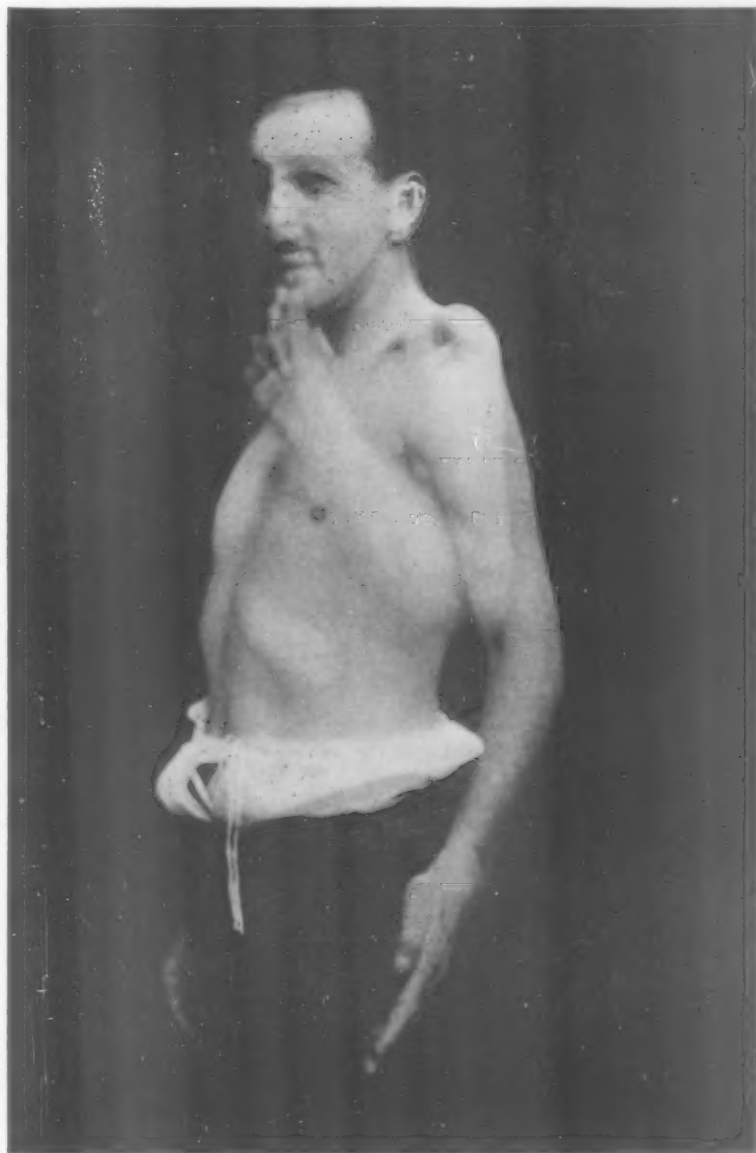


FIG. 27.—Same case as Fig. 25. Superimposed photograph to demonstrate mobility, made on one hundred and sixty-first day shortly before evacuation. At this time patient's function was improving steadily but active abduction was still very limited.

Unresected fractures involving shoulder or elbow-joint, whether infected or sterile, are likely to limitation of motion or ankylosis. We have, however, at least one case of shoulder-joint and one case of elbow involvement

who were discharged with a note that motion was good. Both these had remained uninfected and progressed similarly to uncomplicated fractures of the shaft.

4. *Fractures of the Shaft.*—Exclusive of those eventuating in death or amputation fractures of the shaft may be considered under four headings: (a) Cases of non-union; (b) Cases of delayed union; (c) Cases of prompt union in whom restoration of function is retarded; (d) Cases with "uncomplicated" course.

(a) *Non-union.*—Six cases are included in this class, five of whom had marked loss of substance in continuity. These five will probably not unite



FIG. 28.—Pvt. Johnson. F. C. C. right humerus with loss of substance. Admitted the fifty-ninth day, he was discharged the one hundred eighty-ninth day without union. Radiograph shows the loss of substance, a sequestrum at the lower end of the upper fragment (later removed), and a marked absorption of the lower fragment.



FIG. 29.—Pvt. Keefe. Double compound fracture of left humerus. Lower fracture has united. As can be plainly seen, there is extensive loss of bone from sequestration at site of upper fracture. Sequestra removed eighty-first day. Union delayed on account of loss of bone substance, but will ultimately take place as the gap is bridged by bone-forming tissue.

without operative interference, although, as none of them were under observation longer than one hundred and twenty-five days, this is not certain (Fig. 28). One patient in our series was not recorded as united until the two hundred and twentieth day.

There remains one case who, it would seem, might fall into the class of pseudarthrosis, without loss of substance to explain it. He was operated on the one hundred and third day for non-union, the ends of the bone being freshened. On the one hundred and fiftieth day, he was evacuated still ununited. For those inclined to think that this failure is due to the method of suspension it is only fair to add that the patient was not received for treat-

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ment until the thirtieth day; in other words, after the usual period for beginning union; and that on the fiftieth day he was put in plaster.

(b) *Delayed Union*.—Delayed union in gunshot fractures ordinarily is essentially a matter of bone destruction, depending primarily on the original injury, and secondarily on the subsequent infection. Under this caption are included seven patients. Four were noted as consolidated on the one hundred and twenty-third, one hundred and thirty-seventh, one hundred and fifty-second and two hundred and twenty-third days respectively; three of these had had sequestrectomies. One was evacuated with beginning union, although without consolidation, at the end of three months. He had had an extensive resection of bone fragments at the primary operation.



FIG. 30.—Sgt. Yort. F. C. C. right humerus. Considerable degree of comminution. Persistent musculo-spiral paralysis. Union noted as firm on forty-seventh day, at which time a good-sized sequestrum was removed. Arm kept in suspension for some time further on account of infection. Large secondary abscess had to be evacuated. Return of function slow. On account of paralysis outlook for limited usefulness only.

The other two were evacuated on the one hundred and eighth and one hundred and eighteenth days respectively, before union had actually manifested itself (Fig. 29). They are included as cases of delayed union because there was every reason to believe that it would ultimately take place. Both had sufficient bone damage at the original injury to cause, together with the subsequent infection, extensive sequestration. The sequestrectomies in these cases were not done until comparatively late, with the result that the repair process was undoubtedly retarded. Both, however, have in spite of considerable loss of bone, a continuity of bone-forming elements. Following their sequestrectomies the local condition began to improve.

There remain two other cases who should be classified either as delayed

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union or non-union, but were not under observation long enough to determine which. The first was a Frenchman who was evacuated at the end of three

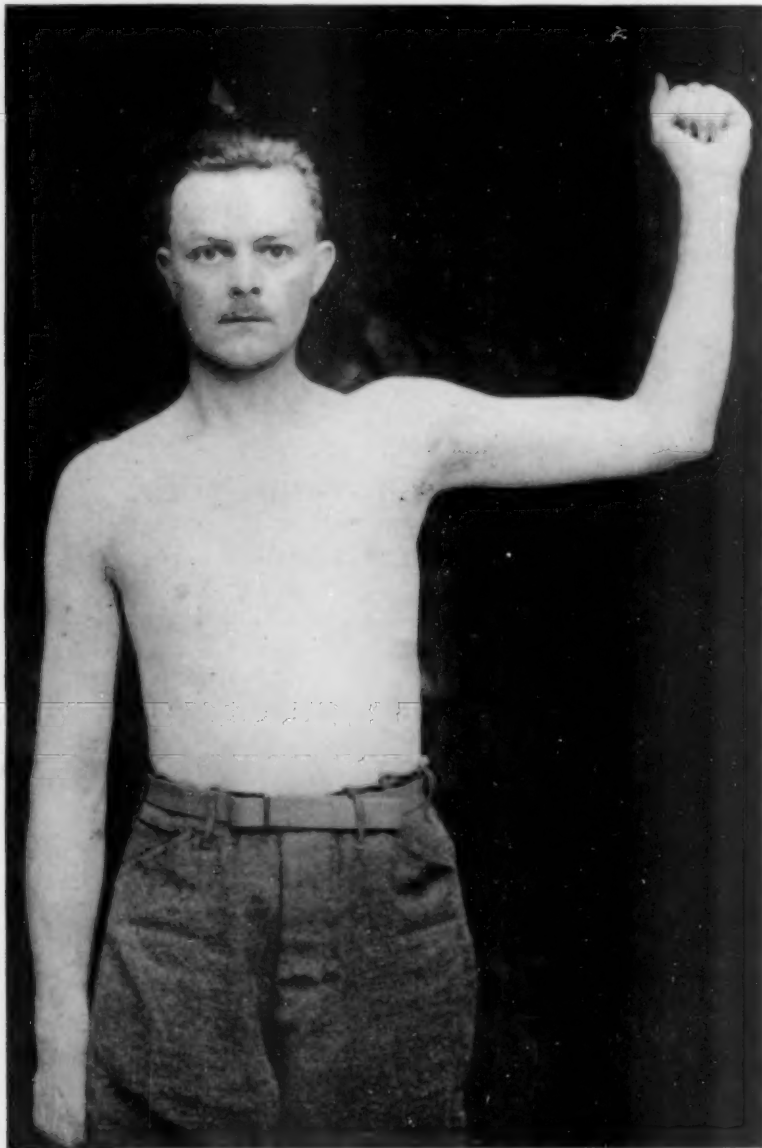


FIG. 31.—Pvt. Hobday. P.C.C. left humerus. See Figs. 11, 12 and 13 for radiographs. Taken eightieth day. Patient was suspended until forty-fifth day.

months without union. His condition suggested a muscle interposition. The other was an American with a transverse fracture. He developed a large terminal sequestrum on each fragment. He was evacuated the one hundred and fifteenth day ununited.

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(c) *Cases in Whom Function is Retarded in Spite of Union.*—In cases of delayed union the prolonged treatment of the fracture is a cause of functional disability which in turn requires prolonged treatment and may never be

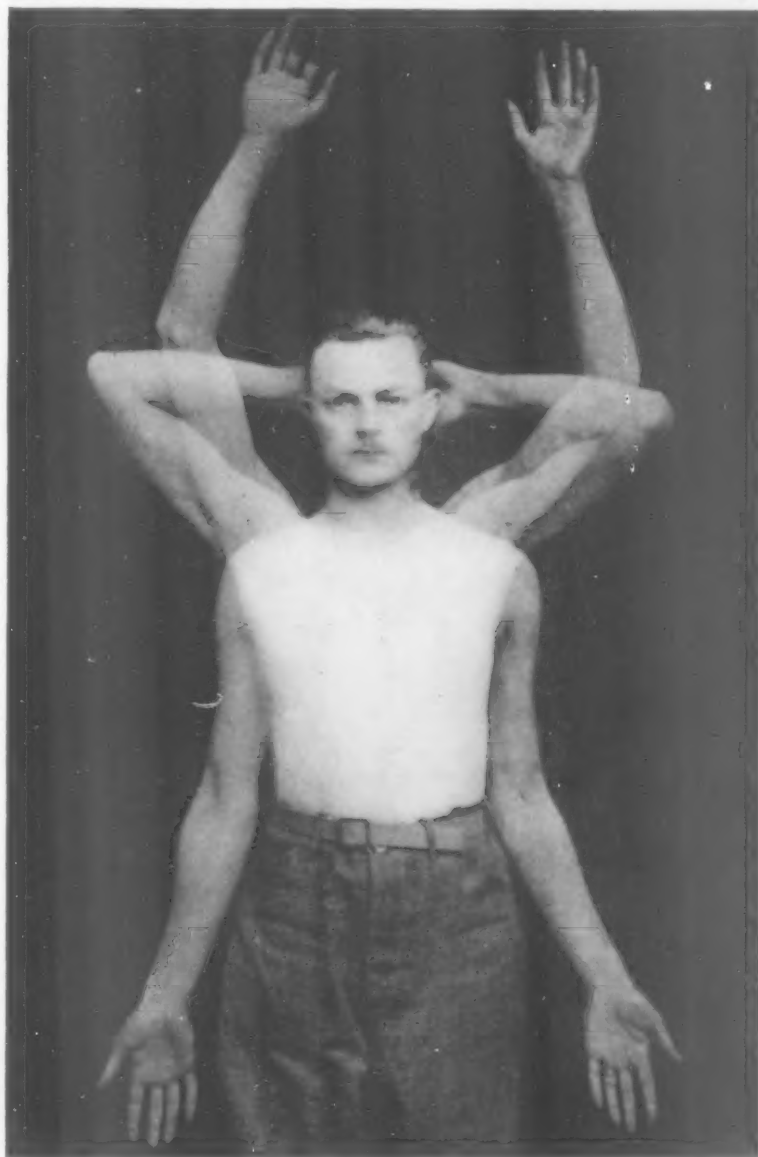


FIG. 32.—Same as Fig. 31. Superimposed photograph made eightieth day.

wholly overcome. On the other hand, there are certain cases in whom union takes place promptly enough, but in whom function is distressingly delayed. What are the causes?

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In the first place, there is often tremendous damage to the musculature of the arm in these gunshot wounds. Function in the muscles involved

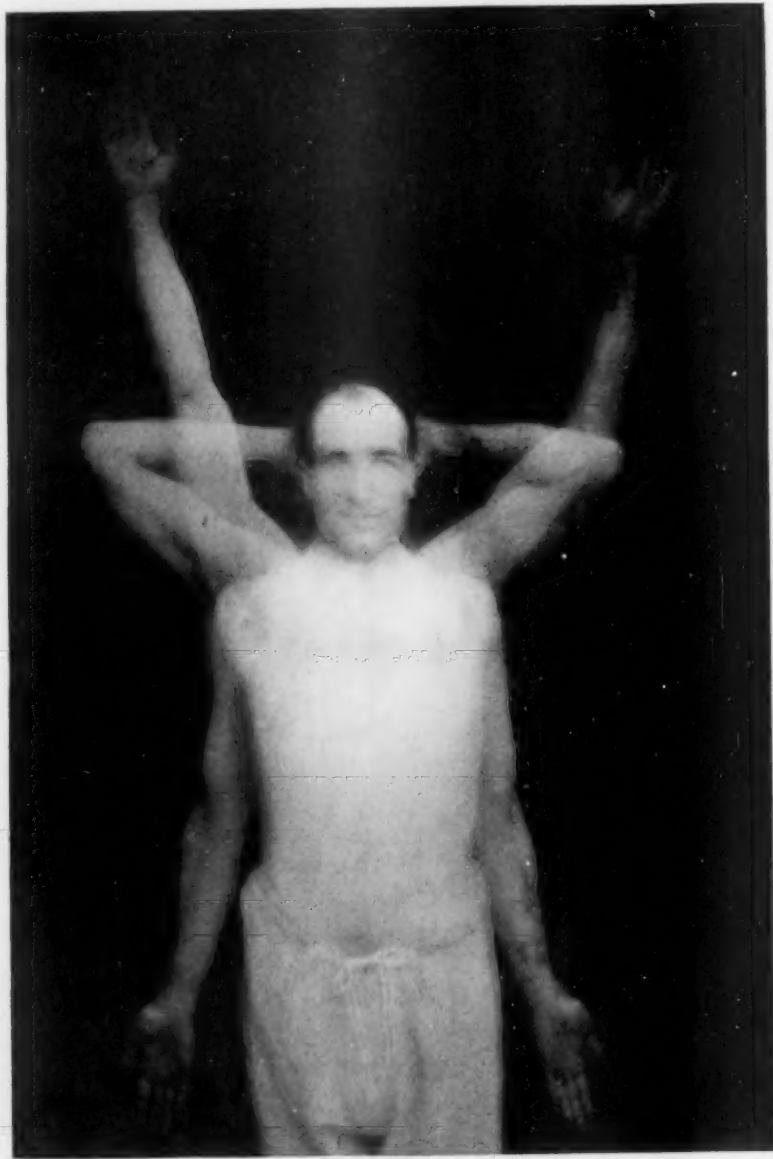


FIG. 33.—Pvt. Woodville. F. C. C. left humerus. Noted as having beginning union twenty-fourth day, firm union forty-fifth, and taken out of frame fifty-first. Superimposed photograph made eighty-first day.

may be paralyzed for a long period after the injury, and when repair takes place there are scar tissue and adhesions to be overcome. Secondly, in those cases with nerve injury, the partial paralysis reacts unfavorably on restora-

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tion of function in the joints and non-paralyzed muscles. Last, but not least, is infection. We have seen that infection is the all-important cause of hospital



FIG. 34.—Pvt. Gerristead, F. C. C., left humerus. See Figs. 16 and 17 for X-rays. Photograph made eightieth day. Noted as consolidated thirty-fifth day and out of frame forty-second. This patient's return of complete function was not as rapid as many. He is recorded as having had an elbow-joint involvement (although the lateral X-ray does not suggest it), which probably accounts for the retardation in his case.

deaths in these cases. It contributes its full share to disabilities. Prolonged sequestration, abscesses, undue scar tissue formation, and more or less chronic disturbance of circulation are all dependent on it. All retard the

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use of the arm, and may necessitate its being kept quiet for weeks after the bone is firm. Is suspension and traction to be blamed for any of these cases

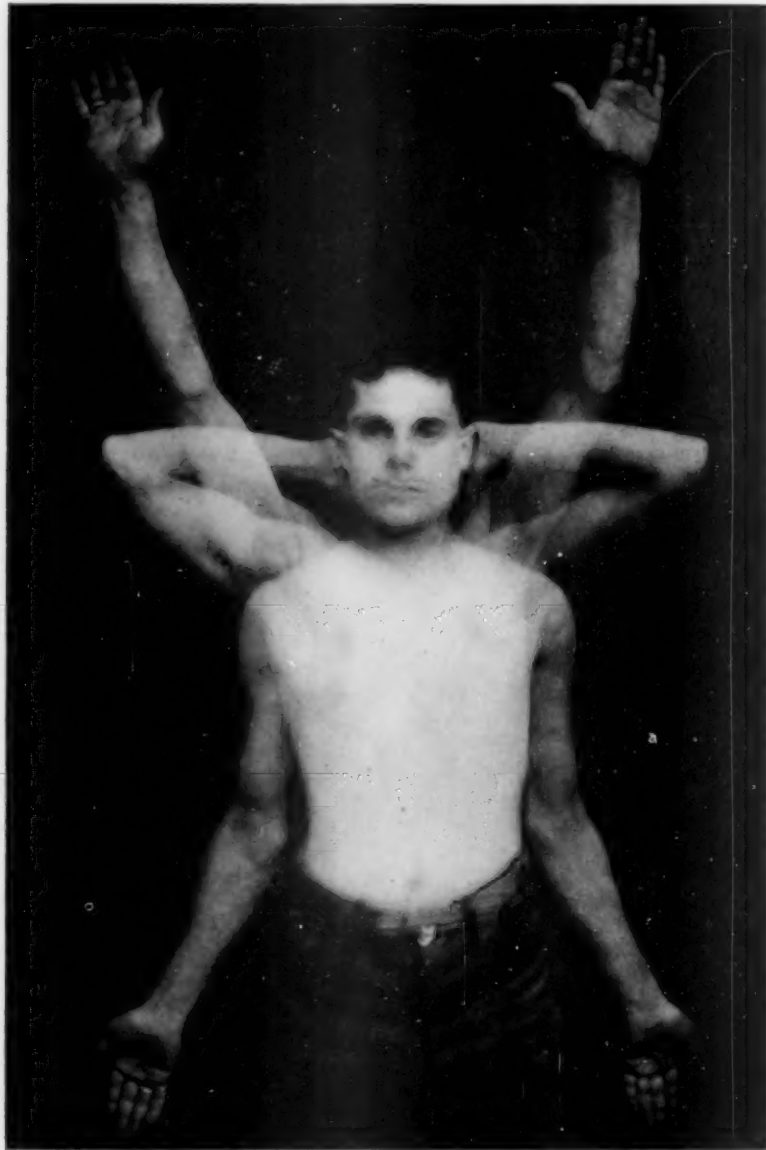


FIG. 35.—Pvt. Finazzo. F.C.C. left humerus. See Fig. 21 for X-ray. Noted as having beginning union thirtieth day. Out of frame the forty-sixth day. Photograph the eightieth day.

of delayed union? On the contrary, it offers comfort and postural advantages, which can be obtained in no other way, so that it is often worth while to continue it even after bone union has been established.

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Of our series of cases four whom we had under treatment from an early date after they were wounded, and five admitted between one and two months afterward, illustrate this class of delayed function. Of the four first men-

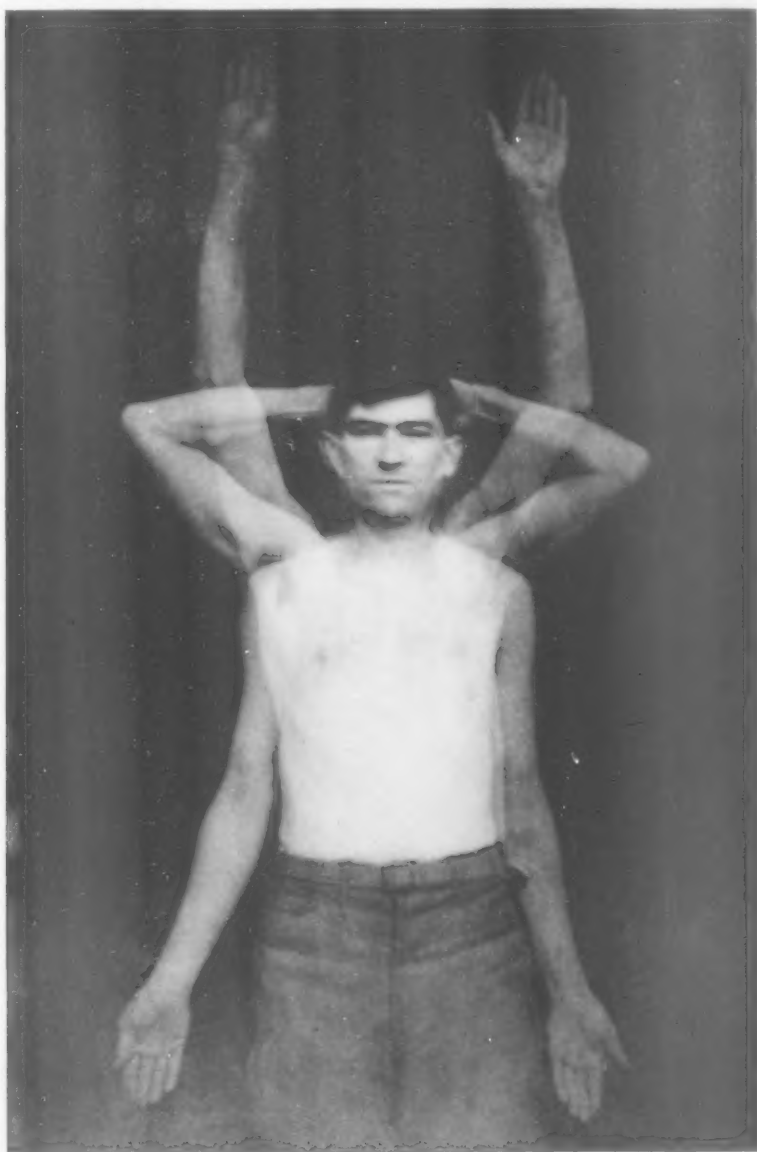


FIG. 36.—Pvt. Moulton. F.C.C. left humerus. See Fig. 22 for X-ray. Noted as having beginning union thirtieth day, consolidating forty-fifth. Sequestrectomy done forty-sixth day.

tioned, at least two had extensive wounds, three musculospiral paralysis, three prolonged suppuration, two sequestration and one erysipelas (Fig. 30). Of the five admitted between one and two months, four had sequestration and

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abscess formation. The function of the shoulder was limited in the fifth by a large scar extending from the arm to the chest.

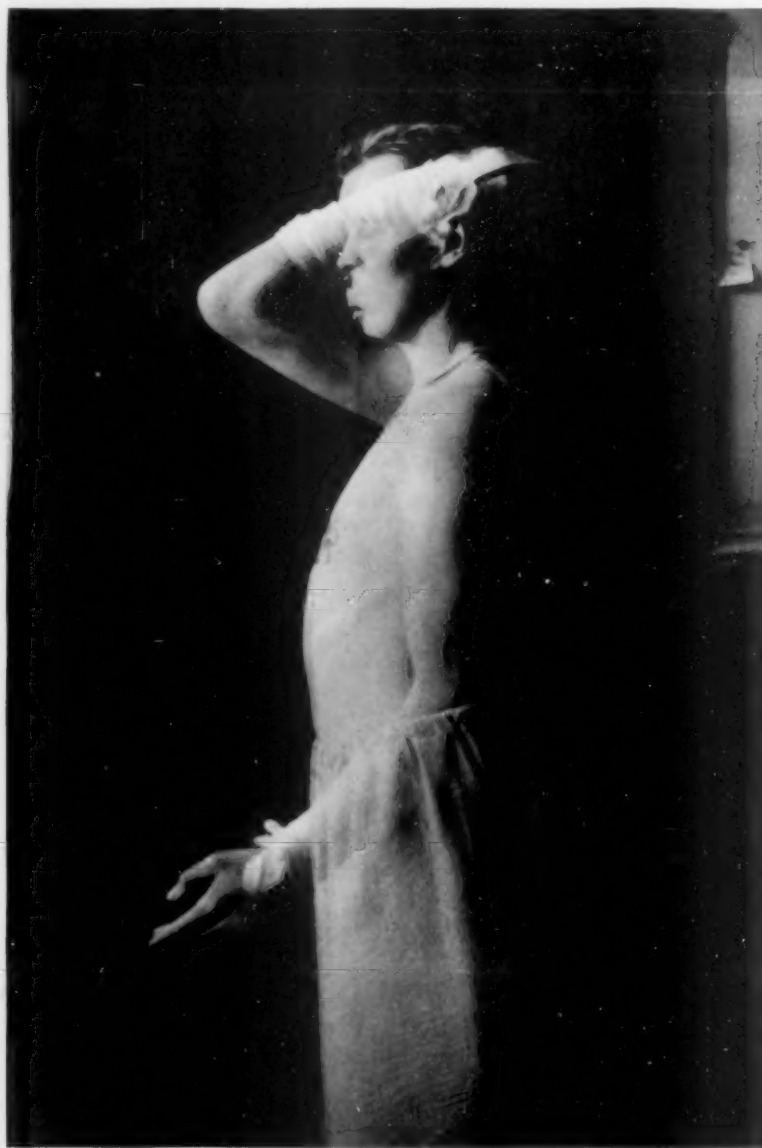


FIG. 37.—Sgt. Dustin. Simple fracture left arm. Recorded as having beginning union twenty-eighth day. Photograph made forty-fourth day. Note extension bands on forearm. At the time this photograph was made patient had not been released from apparatus on account of tendency to anterior bowing, which had manifested itself a week before, at which time he had been out of bed for parts of two or three days. Discharged to duty (ambulance service) sixty-fifth day.

(d) *Cases with Uncomplicated Course.*—After eliminating the misfortunes and the complicated cases among gunshot humerus fractures, there remain the cases in which repair and restoration progress uninterruptedly.

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They represent the largest class, although the number about to be quoted here is small in comparison with the total, because in the stress of "pushes" patients have had to be evacuated early and rapidly, and historians have often not had the time to record whether union was present or not, much less the extent of functional restoration. This class of cases furnishes the best criterion of a method of treatment, because it allows a judgment to be formed as to the completeness and rapidity of cure ordinarily to be expected.

Twenty-four cases, admitted here shortly after being wounded, have sufficiently full records to be included in this group. Of the eighteen Americans, one-half were evacuated in from 5 to 7 weeks after injury, with comparatively free joint motion, so that it was plain that their cure would be rapidly completed. Of these, two called later at the hospital on assignment to duty as military policemen, some two and a half months after the time of receiving their wound. In one the restoration of function was complete, the other was limited only by a few degrees extension. He had had a temporary musculo-spiral injury (Fig. 20).

Of the other American and French patients, a number who were wounded shortly before the end of hostilities remained at the hospital for a considerable period. The accompanying superimposed photographs best demonstrate their progress in two to three months' treatment.

It is to be said that the photographs were made at a time when it was convenient to get the photographer, and not as soon as the patients could make a good showing. Many of them were able to do as well at a considerably earlier period. Note the preservation of nutrition in the wounded arms (Figs. 31-36).

Before closing, it seems desirable to make reference to three simple fractures which have been treated here by the suspension and traction method. The period required for union averaged about the same as that for our gunshot fractures. As far as can be judged from these three cases, therefore, one need not fear that the lack of comminution in civilian fractures will render them unsuitable for a method which does not immobilize. The accompanying photograph (Fig. 37) of one of them, made before the arm was sufficiently solid to release altogether from the apparatus, shows the possibilities as to maintenance and recovery of function. It seems to those who have worked with this method that its potentialities should make it an important aid in the treatment of simple fractures of the humerus, more especially those that tend to deformity, even though it is admitted that it will often be difficult to confine patients with fractured humerus to bed.

To summarize, suspension and traction in treatment of gunshot fractures of the humerus offers the following advantages: Favorable posture for treatment of the wound; maintenance of reduction for any type of fracture; and early recovery of function. As in the treatment of fractures by any method whatsoever, experience and painstaking supervision on the part of the surgeon are necessary to secure the best results. In a fracture ward, specially trained nurses should be employed. The more experienced one

becomes in the use of suspension and traction in the treatment of fractures the more its possibilities challenge interest and effort, and the better will be the results obtained.

I wish to express thanks to Dr. Joseph A. Blake, under whose inspiring guidance these patients have been treated, and who has kindly given help and encouragement in the preparation of this paper.

The photographs were made by Museum Unit No. 1, Major Robert Ross, whose interest and coöperation greatly facilitated the work.

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FRACTURES OF THE LOWER THIRD OF THE FEMUR *

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THIS type of fracture has always been considered one of the most serious on account of its complications. The compounding of these fractures during the war has considerably complicated the treatment. The lower fragment under the action of the gastrocnemii is regularly pulled backwards; any traction on the straight limb will increase this displacement.

We divide open fractures by missiles into three different types. Fractures with: 1. No comminution. 2. Slight comminution. 3. Much comminution.

For each of those types we at La Panne used three different methods of treatment. Those methods are: 1. Wiring. 2. Traction on the femoral condyles by ice-tongs, Steinmann pins, or Willems screws. 3. Depage's vertical suspension of lower fragment combined with horizontal traction on the leg.

The first type of fracture, produced by a bullet at long range or a shrapnel ball or small shell fragment at the end of its flight, has little or no comminution. The soft parts are only slightly lacerated. This is the ideal case for wiring. If, after débridement, we plan to make a primary suture of the wound, we use Depage's wiring method, because the metallic tube that sustains the wire projects out of the wound and affords good drainage. If, on the contrary, we plan to make a secondary suture, we use a Parham or a bronze wire which we remove after a month before suturing the wound. It is understood that wiring only can be used in oblique fractures. In transverse fracture we use the ice-tongs or vertical suspension. In a few cases we have used Lane's plates with good result and without any complication. We do not, however, recommend the introduction of screws in open contaminated fractures. The wiring method seems to us the ideal method for the open fractures of the lower third. It gives a perfect reduction, requires little postoperative attention and permits the suspension in a Thomas or Blake splint.

In the second type we have to deal with slightly comminuted fractures; the soft parts are extensively lacerated, the débridement must be thorough, the fracture carefully explored and all loose fragments of bone have to be removed, but the continuity of the bone is assured by large adherent bone fragments, well supplied with blood. Primary suture of the wound is dangerous; therefore we always plan to make a delayed primary or a secondary suture. Those are the cases in which we use the ice-tongs or Steinmann pins if a low wound does not contra-indicate their employ-

* Read before the American Surgical Association, July 16, 1919.

ment. Willems screws are not to be recommended; they hold badly in the cancellous tissue of the condyle; they loosen under traction, cause pain by pressure on the skin and finally pull out after two to three weeks.

The Steinmann pin seems to us the best method, the knee-joint being bent. Ice-tongs are also good. It is best to place the pin just above the condyle; unfortunately the neighborhood of wounds prevents us very often from doing this; we have then to pass it through the condyles; it is very important that it should be passed in the anterior part of the condyle. Therefore, we have to put it in place under the control of a fluoroscopic screen as was recommended by Fesson. The reason therefor is the following: The condyles rotate on the tibia; they constitute a half circle, the axis being transverse approximately through the centre of each condyle. We could also compare this to a wheel. When the pin is put through the condyles behind the axis and traction is exerted the wheel rolls backwards and thus increases the displacement backward of the lower fragment. On the contrary, if the pin is passed anterior to the axis the wheel will roll forward and the backward displacement on the lower fragment will be corrected. We believe that the pin should not be left in place more than six weeks. The vicinity of an infected wound is a constant danger of infection, so much the more serious because it threatens the knee-joint.

The third type is the much comminuted fracture; the bone is completely destroyed for a distance of one or two inches, the exit wound is large and dirty; the débridement in those cases has to be carried out very carefully and thoroughly on account of the danger of gas bacillus infection. Practically all the bone fragments are detached and have to be removed; there is an important loss of bone substance that might give a non-union, but this may not occur if a bridge of periosteum is present. The treatment here will be very long, lasting several months. For those cases we use the vertical suspension. This is accomplished by passing a bronze wire through all the tissues of the anterior part of the thigh with a Reverdin or a Moor needle. A finger introduced in the wound catches the wire and fixes it securely around the end of the lower fragment. Traction is made by a weight hanging above the bed of the patient, connected by a cord with the end of the wire.

Shortening of the femur is prevented by traction with a Chutro stirrup or Gilliam's method. This suspension can be maintained during months. Some of our fractured femurs were kept for three months with this apparatus and the presence of this wire did not pain them at all nor did it do any harm or cause any complication.

We have also used this method with excellent results in cases of the lower third badly united and complicated by a streptococcic fistula. Here we recommend the subperiosteal resection of the osteitic callus and vertical suspension of the lower fragment. Those cases have done wonderfully.

We may summarize as follows:

1. In oblique fractures with little or no comminution, wiring.

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2. In fractures with slight comminution when we expect a beginning of consolidation within the six weeks, ice-tongs or Steinmann pin.

3. In all the cases where one of the aforesaid methods cannot be used and where the consolidation is expected to be delayed a very long time, we use the vertical suspension of the lower fragment, combined with a horizontal traction on the leg.

DISCUSSION

MR. W. HEY GROVES, of England, while largely in accord with Dr. Van de Velde's principles of treatment, believed that the number of fractures with no comminution which required wiring was very small, and that the operation should be limited to those cases in which the widely separated fragments showed a real danger of intervention of the soft parts. Even in those cases the efficient extension apparatus available lessened the need of operation. In the treatment of the second type in Dr. Van de Velde's classification Mr. Groves believed that a pin directly through the lower end of the thigh would inevitably act as a seton, and that in a small definite proportion of cases, in his own experience 3 per cent., sepsis would occur. This danger would be entirely eliminated by tibial transfixion. Since the six weeks, beyond which Dr. Van de Velde said the ice-tongs or Steinmann pins ought not to remain in place, would not see the case through, a measure of the greatest possible value in Mr. Groves' opinion was the transfixion of the tibia and the adjustment of a weight extension.

DR. JOHN B. WALKER, of New York, said that only by the end results in fracture cases would the best means of treatment be determined. In this connection he expressed the hope that a certain amount of public opinion might be conveyed to the office of the Surgeon General, urging that the records of war injuries might be rendered accessible for study.

DR. JOSEPH A. BLAKE, of New York, regarded tibial traction as comparatively safe from the standpoint of infection, because in war injury the wounds extend farther down toward the knee, often interfering with a pin in the femur. In tibial traction, however, there was lost much control of the lower fragments, which was the important factor in the treatment of fractures. In every case where practicable to have the traction upon the femur it should be done.

THE CONTRIBUTION OF THE WAR TO THE SURGERY OF THE KNEE-JOINT*

By BURTON JAMES LEE, M.D.

OF NEW YORK

THE war having ended, it should be our immediate aim to consider the new surgical chapters written in the great conflict, and to adapt such of them as we may to the surgery of civil life. One hears occasionally that some men returning from abroad have brought back no new thing to civil surgery, but such a barren result must mean a limited experience or a non-receptive mind. Among the many important contributions may be mentioned: The Principles of Débridement in Wounds; The Sterilization of Infected Wounds; The Possibilities of Primary and Secondary Suture; The Vast Accumulation of Data Upon Fractures and Osteomyelitis; The Large Experience in Nerve-Suture Work; The New Chapter in the Radical Surgery of the Lung; The Demonstration of the Non-Wisdom of the Expectant Treatment of Abdominal Wounds, the First War to Accomplish this Result; and lastly, as important as any other contribution, The Establishment of the New Method of Treatment in Joint Surgery.

The object of this paper is to place concisely before the American surgeon, the real facts concerning the great addition, made by the war, to the surgery of the knee-joint. Willems, the Belgian surgeon, advocated and began to practice in 1915 the treatment which now bears his name. A complete description of this method is scarcely necessary. In September, 1918, the writer published a detailed account of the method, the paper having been written the preceding January, but it was delayed in transmission. It may perhaps be well, however, to briefly summarize the basic principles of Willems' treatment.

Willems' treatment of a wound of the knee-joint may be briefly outlined as follows:

1. Accurate foreign-body localization.
2. Careful débridement of all soiled and devitalized soft tissues and soiled bone.
3. Removal of all loose bone fragments and foreign bodies.
4. Irrigation of the joint with saline.
5. Filling of the joint with ether.
6. *Primary closure of the joint by suture, usually including the skin.* With considerable injury to knee or muscle, it is wiser to close the joint capsule, but leave the skin and muscle unsutured.
7. *Early and frequently repeated active motion of the knee*, no splint being applied, save with massive bone injury. This mobilization is

* Read before the Sharon (Conn.) Hospital Association, July 19, 1919.

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begun upon the second day, and is continued at two- or three-hour intervals. The patient is up about the ward, with crutch support, on the fourth day, and is encouraged to walk without any support by the tenth day.

The treatment of infected knee-joints was outlined by Willems in the following manner: Opening of the joint through sutured wounds or by lateral incision, no drains of any kind being introduced. Active mobilization was continued, as with the non-septic knees, the patient being awakened at two-hour intervals, night and day, and encouraged to move the joint. As soon as practicable the man was compelled to get up out of bed, and to use the leg in as normal a manner as possible.

The advantages of this treatment of wounds of the knee-joint were a quicker recovery, a higher percentage of good functional results, and an active soldier back in the line in a few weeks. Many of the cases of septic joints obtained normal functioning knees. Surgeons generally were, however, inclined to be very dubious about such a radical departure. The technic seemed to be in such absolute variance from established surgical principles and practice that some at first concluded that the effort was a sort of fad, and paid little heed to the new doctrine. Later, when Willems showed in Paris a considerable number of his end results, the truth was evident at once, and the principle of treatment was accepted by most as sound and reasonable.

One may properly inquire what the general opinion has been and is:

A. Abroad, among the surgeons of the A. E. F., at the time of the Armistice.

B. Here, at home, now.

A. In the latter part of November and December, 1918, in company with Major Mixter and Major Kerr, I was privileged to visit all of the evacuation hospitals and mobile units of the American Army, and later, every base hospital in France. The object of this visit was to collect data for a certain report to be made upon the end results in certain special types of cases. Among other classes of patients, results in wounds of the knee-joint were collected and opportunity was afforded to gather information from various surgeons who had operated both in the advanced and base areas. Rarely, one would meet a surgeon who was rather enthusiastic about the results of active mobilization of joint injuries, and he was usually a man who had had service in the advanced zone, and also some work in a base area. In general, however, we had a very definite impression that the surgeons, as a rule, were unenthusiastic and more or less hopeless about this new treatment of joint injuries. They usually stated that they had had few good results as to function of the joint, and that most of the cases had come down to the base sections with infected joints, requiring free incision, and later either resection or more often amputation. Some of the men died of sepsis.

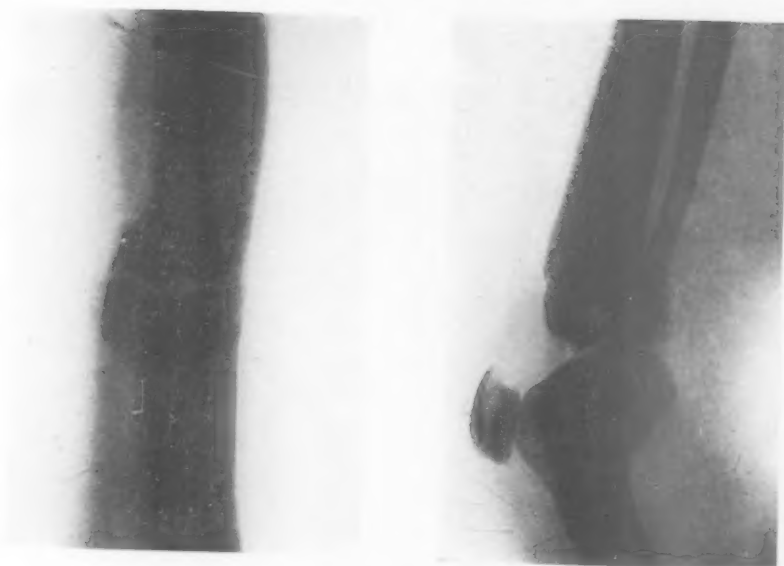
B. Here at home, many men are found who are even now totally ignorant of this new line of procedure, and many who have come from abroad are equally pessimistic about the results obtainable.

What, then, are the reasons for this variation in opinions concerning the soundness of the treatment, held on the one hand by Willems, Delrez, some French, British, and American surgeons, and on the other, by many American surgeons to-day.

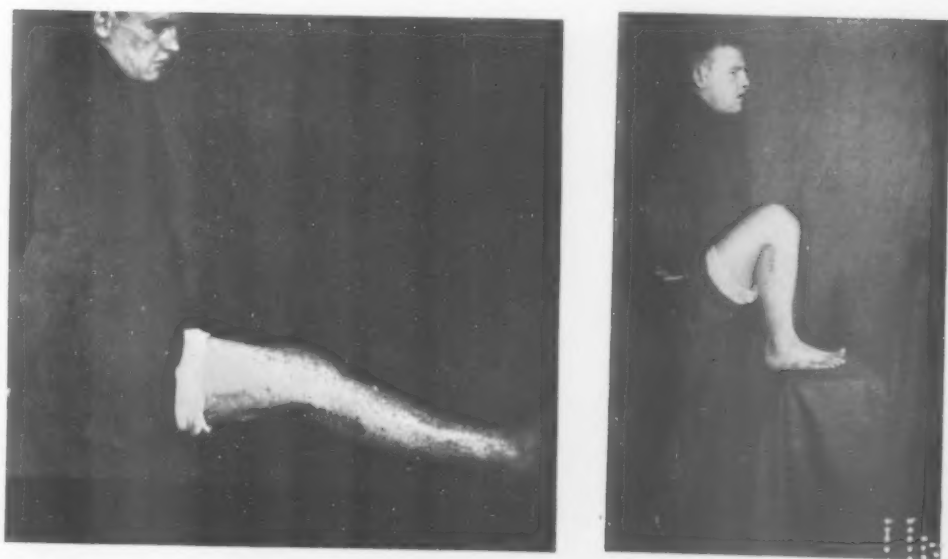
A. The Optimistic View.—Those enthusiastic about knee-joint results have invariably seen cases from quiet sectors with fixed lines where the surgery developed has been carefully systematized, and ideal conditions have existed for surgical work. Cases were evacuated from the front line trenches into a well equipped and carefully organized hospital, and most patients were on the operating table within a few hours after injury. Skilled surgical treatment was always available and the efficient after care of every type of case lay in the hands of the man best qualified to handle it. I was very much impressed by the careful, painstaking work of Doctor Delrez at La Panne with the joint cases there. The entire morning was spent on rounds, and each patient with a joint injury was encouraged to move his joint under Doctor Delrez's personal supervision. The operative technic carried out on these cases was finished, a clean dissection being made with the smallest amount of traumatism possible. The work was never hurried, and when the operation upon the joint was finished, one had the conviction that a careful débridement of all soiled tissues had been accomplished.

In the considerable number of knee-joint injuries in Doctor Delrez's service, the results were really excellent. Even in the cases in which infection occurred, active mobilization of the joint was continued without ceasing. Upon morning rounds, the patients with infected knee-joints who had not been following out the principle of active mobilization could readily be picked out without even questioning the man, as the higher temperature and the man's complaint of pain testified at once that the joint had not been moved. In other words, the only efficient drainage of a septic knee-joint that is possible is the movement of the joint itself. Dressings applied should not be confining, that they may interfere as little as possible with joint movements. It is indeed a weird experience to see a man walking about a hospital ward with a considerable opening over the knee-joint, through which one may look directly into the joint cavity, and from which is exuding thin, purulent material, and yet see this man bend his knee and extend it to the normal ranges without any pain and walk about with perfect comfort.

B. The Pessimistic View.—In contrast with these ideal conditions on certain sectors of the front, the problems confronting the medical corps of the United States Army were most of the time difficult and very complicated, due to the activity of the campaign and the evacuation necessities of the wounded. A further analysis of the reasons for some of the



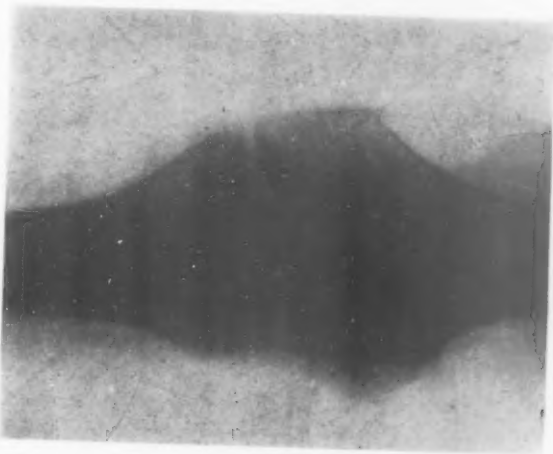
FIGS. 1 AND 2.—Penetrating bullet wound of right knee-joint.



FIGS. 3 AND 4.—A. Hoyois. Service of Dr. Delrez of La Panne. Penetrating bullet wound of right knee-joint. Open operation. Primary closure. Immediate mobilization. Picture taken three and a half weeks after operation. Joint function normal.



FIGS. 5 AND 6.—G. Neuteleers. Service of Dr. Delrez of La Panne. Penetrating shell wound of left knee-joint. Suppuration after operation. Six weeks post-operative. No pain. Large return of function. Normal use of joint although anterior opening into joint still persists.



FIGS. 7, 8 AND 9.—Penetrating shell wound of right knee-joint with marked splintering of patella and internal condyle. Patella and part of condyle removed. Suppurated.



FIG. 10.—Shell wound of right knee-joint; posterior view of case shown in Figs. 7, 8 and 9.



FIG. 11.—Shell wound of right knee-joint showing method of support and dressing case shown in Figs. 7, 8 and 9, four weeks after operation. Flexion of joint. Extension by pulleys. Later plastic operation on extensor tendon gave useful joint with brace.



THE SURGERY OF THE KNEE-JOINT

poor results in knee-joint surgery revealed the fact that the case had passed through several hands up to the time that it had reached the base area. Although the man in the advanced hospital may have started the treatment along perfectly proper lines, the active mobilization was frequently discontinued during a trip down in the train or in the hospital farther to the rear, and the whole early treatment was vitiated. It is almost impossible to get a knee-joint back on active mobilization if the man has been allowed to keep the knee immobile during a period of several days. In some instances, a surgeon in an advanced hospital may have done a careless débridement of the joint, and any type of treatment following such a procedure would necessarily be ineffective. In times of great push, evacuation was so difficult through roads packed and jammed with supplies, guns, ammunition, troops and ambulances, that wounded men could not reach their first hospital for operation in from fifteen to twenty or thirty hours. Under such conditions, the ultimate results of knee-joint injuries would necessarily be less favorable. The marked exception to the conditions present along the American front was the situation at American Evacuation Hospital No. 1, near Toul, serving most of the time a fairly quiet sector of the line. Picked surgical talent was assigned to carry on the clinical work here and the whole setting for ideal surgery was complete. Although no accurate figures are yet at hand telling the end results of any particular group of cases, I believe one can say without exaggeration that the surgical work done upon joints in this institution will compare favorably with that of the best surgery of the other armies, and that the end results in the joint cases treated here were excellent.

Conclusions.—American surgeons will, therefore, not attempt to carry over into civil practice the technic and type of treatment which we have outlined as present under conditions of push in the American Army abroad. The best surgical judgment will rather seek out some institution or institutions where a quiet line and a well-organized stable hospital, furnishing the best of surgery under ideal conditions, gives the nearest approach to civil practice. We may have absolute assurance that the same results may be obtained at home as these picked hospitals furnished, and we may confidently believe that the treatment proposed by Willems and practiced by himself, Delrez, and many others, is sound and here to stay, and represents one of the outstanding contributions which the war has brought to civil surgery.

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POCKETING OPERATIONS AND OTHER SKIN AND FAT TRANSFERS.*

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THE so-called pocketing operation of Italian origin, and other plastics, whereby skin and fat are transferred from one portion of the body to another, are of very great value in the elimination of deforming scar tissue and in the conservation of important structures. Several portions of the body are covered by freely mobile elastic skin underlaid with a plentiful layer of fat. By making use of some of the plastic procedures described in this article, it is possible to take skin and subcutaneous fat from areas where it can be spared and transfer it to localities where it is very badly needed. Managed with a reasonable degree of judgment and skill, the method is practically certain of success.

Grafts in the course of time usually take on the appearance of the skin of the region in which the implant is placed. For instance, a transplant from the upper arm to the nose loses its hairs and takes on a characteristic oily appearance. Transferred flaps, while at first anæsthetic, eventually regain the sense of touch through the projection of sensory nerve fibres from the surrounding tissues. The confinement of the operated part in a comparatively fixed position is tedious but not painful. Some of the indications for the transfer of skin and subcutaneous fat are: For the purpose of filling deep depressions caused by the loss of portions of the bony and soft structures of the body. The restoration of the soft parts preliminary to certain operative procedures on bone and tendon. For the purpose of replacing large deforming scars of low vitality (Figs. 1 and 2). To cover raw surfaces left by the excision of granulating areas, or by the débridement of bone sinuses. To round out and put in proper condition for weight-bearing, painful and unhealed stumps. To cover recently denuded bone, such as the fingers after severe lacerating and crushing injuries. The technic is simple but must be exact. Flaps for the face, neck and nose are usually taken from the upper arm. For the eyelids the thin skin from between the fingers is well suited. For the hand, fingers, forearm and wrist, transfers are made preferably in most cases from the abdominal wall, but also from the chest, back, gluteal region, outside, front or inner side of thigh, and from the opposite arm. For the feet and legs transplants are taken from the calf or thigh of the

* Authority to publish granted by the Surgeon General, U. S. A., July 17, 1919.

opposite side. The posterior surface of the thigh is a suitable place from which to take a flap for the leg of the opposite side.

The flaps are cut either single- or double-ended, as the exigencies of the case may demand. They are cut about one-third larger than the actual measurements would seem to call for, so as to allow for shrinkage and to avoid tension. The flaps are cut with a generous layer of underlying fat which carries a good blood supply as well as giving a full measure of protection to tendons, nerves or other important structures lying underneath. If a sufficient thickness of fat is used to make the implant rise above the level of the surrounding tissues, the excess of fat will ultimately be absorbed, as nature's constant effort is to restore the natural contour of the body. During the process of healing in place, all skin transplants thicken slightly, but the excess of tissue disappears with use and time.

Hæmostasis must be thorough. The bleeding point only is caught with light forceps. Double zero plain catgut is used for the ligatures. The statement sometimes made that ligations about such flaps will cause sinus formation is obviously based on theory rather than fact, as in our series of cases, we have made free use of ligatures whenever indicated. The suture of the skin edges of the transplant to those of its bed must be done with care and accuracy. The sutures should be inserted very near the skin edges and should be tied with the minimum amount of tension.

When a comparatively narrow bridge of skin has been taken up from the abdominal wall, the skin edges underneath can be readily approximated without undermining, as the skin at that point is quite elastic. We generally make use of tension sutures of silkworm gut protected on either side with short segments of 4 mm. size rubber tubing.

In some cases the skin edges will have to be undermined and it is at times necessary to cut plastic flaps for the complete covering of the raw surfaces made by raising the transfer flap. In case of a double-ended flap with the arm projected through the opening under the same, the skin surfaces of the arm will tend to come into more or less intimate contact with the chest wall and will interfere with the toilet of the wound of the abdominal wall, making it somewhat difficult to keep the suture line dry and clean. These difficulties can be overcome to a considerable degree by the following expedients: The arm may be slightly separated from contact with the body by the insertion of rolls of gauze at various points, allowing a circulation of air about the wound and avoiding sweating and maceration of tissues. A bridge made of wire, as shown in cut (Fig. 3), is used to accomplish the same result as the rolls of gauze previously mentioned. No gauze or other conventional dressing materials are applied to the operative wounds incident to these plastic procedures. Gauze would only serve by the foreign body reaction to cause irritation and exudation of serum from the raw surface at the base of the flap. The skin surfaces are carefully cleansed with alcohol, ether or Carrel-Dakin solution, several times a day. The wounds are frequently exposed to direct sunlight or to electric light in cold or cloudy weather.



FIG. 1.—Large scar and two sinuses of ulna suitable for operation.



FIG. 2.—Case suitable for bridging operation.



POCKETING OPERATIONS

The length of time required for these flaps to develop a new blood supply sufficient to maintain viability after the ends of the transplants are detached from the body varies considerably for many reasons. Some surgeons have assumed that ten days is a sufficient length of time, others say fifteen days, but personally we have found it better in most cases to wait for about three weeks in order to insure complete success. If the time has been too short there is apt to be some loss of tissue by necrosis at the severed edges. When a double-ended flap has been used, it is often advantageous to detach one end a few days previous to the other in order that the ensuing circulatory disturbances may not be too abruptly brought about.

After both ends of the transplant have been detached they are cut to correct shape, the raw edges slightly undermined and sutured in place. In order to secure primary union it is highly important to excise all granulation tissue about the flap edges previous to suturing. The small raw surface at the base

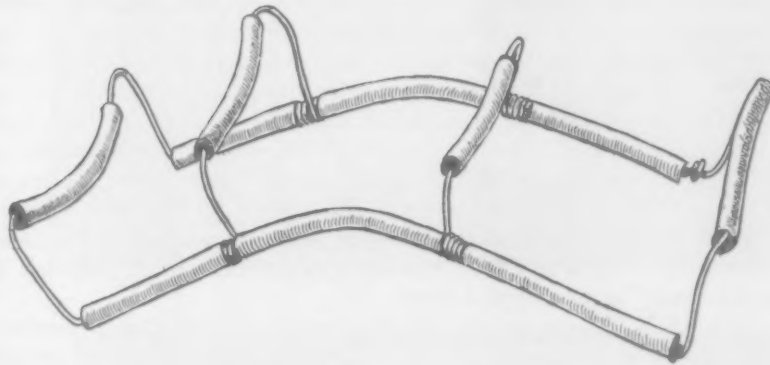


FIG. 3.—Wire support for arm.

of the flap on the body is treated in a similar fashion. The previously described dry treatment with exposure to electric light or sunlight is continued until healing has taken place.

The following case histories are appended:

CASE I.—Pvt. D. High explosive shell wound, middle finger left hand. Ball and tip of middle finger made up of very dense scar tissue firmly adherent to the bone. Tender and painful to touch. Operation: April 1, 1919, the scar tissue on end of finger excised. A small flap from the abdominal wall sutured in place. A silkworm-gut suture was carried through the finger nail in order that a snug fit may be secured. Nineteen days later the finger was freed from the abdominal wall and as the graft looked cyanotic no attempt was made to closely trim or to suture the edges of the graft on the finger. A very small portion of this graft became necrotic. The wound was cleansed with alcohol or ether daily and was exposed to the air, constantly being protected by a small wire cage which was placed about the finger. Epithelial prolifera-

tion was rapid and the transplant conformed to the shape of the finger in a short time (Fig. 4).

CASE II.—Private R. received a gunshot wound through the hand at St. Quentin, France, October 17, 1918. Incident to this injury he lost the second and third fingers along with half of the corresponding metacarpal bones of the left hand. The index and little fingers both being quite stiff and widely separated gave the hand a grotesque appearance and looked more like a pitchfork than a human hand (Fig. 5).

Operation: April 18, 1919, scar tissue excised from back and palm of hand. A bridge flap with two convex projections was elevated from the abdominal wall and sutured into position. Twenty-two days later the abdominal ends of this flap were severed. All granulating areas were excised and skin edges sutured. Ten days later massage was instituted and at the present time the fingers have become quite flexible (Fig. 6).

CASE III.—Private K. A gunshot wound incurred at Bar Sur Meuse, November 12, 1918, through the palm of the left hand had caused a densely adherent scar which completely destroyed the use of the flexor tendons of the thumb and all of the fingers except the fourth (Fig. 7). *Operation:* May 10, 1919, large dense cicatrix excised from palm of hand and a single pedicle flap from the right upper chest wall was sutured in place. The hand was kept from actual contact with the underlying suture line by rolls of gauze, no dressings being applied to any part of the wound. Twenty-one days later the flap was severed and the free ends sutured. Under active massage and other forms of physiotherapy, there has been considerable restoration of function in this previously badly crippled hand.

CASE IV.—Private D. A gunshot wound of left thumb received at St. Mihiel September 15, 1918. Amputation stump with densely adherent painful scar, which was sensitive to the slightest touch, was treated by excision of all scar tissue. An abdominal flap of skin and fat was sutured to the denuded area. Twenty days afterward the thumb was released from the abdomen and the flap ends sutured in the usual way. Unfortunately most of this transplant underwent necrosis. This was probably due to the fact that the denudation was not sufficiently extensive and also because a tight dressing was applied after the patient was sent to the ward. April 30, 1919, the scar tissue was removed and a skin fat flap from the external surface of the thigh was used to make a new thumb stump. There was a slight superficial skin infection following this operation, but the ultimate result was good, and the patient was given a painless stump without the sacrifice of any additional portion of his thumb metacarpal.

CASE V.—Private H. A gunshot wound received in Argonne Wood October 12, 1918, destroyed most of the soft tissues of the right heel and a portion of the os calcis. The result was a discharging sinus and a large area of scar tissue which made locomotion difficult without the use of crutches (Fig. 8). The patient was unable to wear a shoe. The scar area was excised and the bony sinus extirpated. The flap in this case was taken from the calf of the opposite leg. Both knees



FIG. 4.—Case I. After completed operation.



FIG. 5.—Case II. Previous to operation.

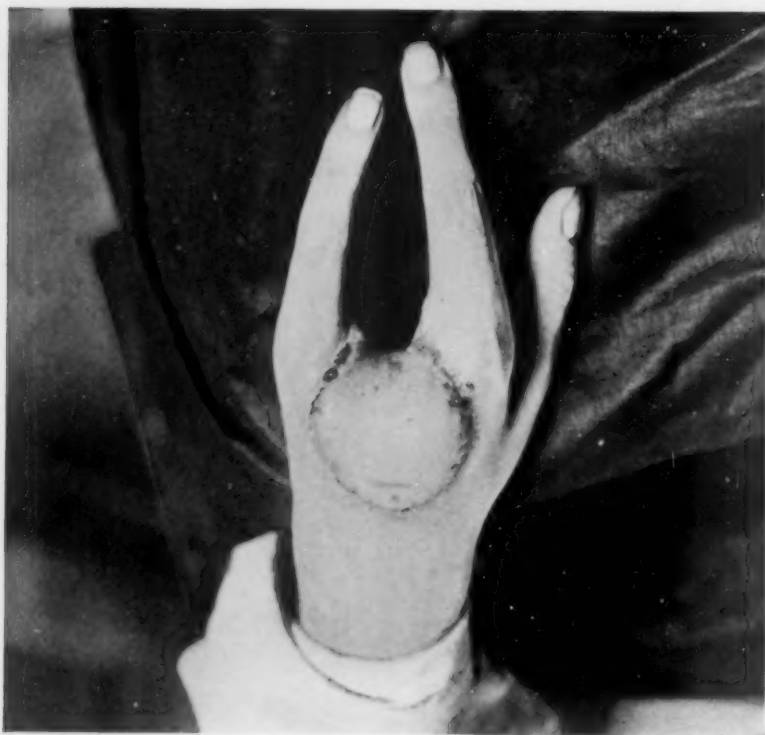


FIG. 6.—Case II. When ready for discharge.



FIG. 7.—Scar of hand in Case III.



FIG. 8.—Case V. Heel previous to operation.



FIG. 9.—Case VI. Flap for thumb. Shows mattress sutures.



FIG. 10.—Case VI. After healing.



FIG. 11.—Larger transfer flap, region of elbow.



FIG. 12.—Transplant on arm after healing.



POCKETING OPERATIONS

were fixed with plaster-of-Paris dressing. The distal portion of the injured foot was also firmly secured to the opposite ankle. A few days later the plaster case was removed and the foot was secured from undue movement by a strip of adhesive plaster. Complete healing resulted. The patient has an excellent weight-bearing surface.

CASE VI.—Private S. A gunshot wound between the thumb and index metacarpals of left hand resulting in a dense mass of scar tissue, which rendered the soldier quite unable to abduct the thumb, was excised on May 9, 1919, and a flap of skin and fat from the abdominal wall sutured in its place (Fig. 9). There was primary union. Secondary operation was done twenty days later. By the assistance of massage the range of abduction of the thumb has been almost fully restored (Fig. 10).

CONCLUSIONS

That skin and fat transplants are valuable for the elimination of cicatricial tissues with their coincident deformities (Figs. 11 and 12).

That by their use superficial sinuses in bony and soft tissues can be eliminated and depressions can be filled.

That accuracy of technic is essential to success in this line of work.

That the suture lines must be kept dry. That the absence of dressings and some form of mechanical support that will prevent the skin surfaces of the arm and body from coming in too close contact are valuable aids.

That months of time are saved the patient.

THE BARREL-STAVE SPLINT IN FRACTURE OF THE CLAVICLE *

BY HUBERT A. ROYSTER, M.D.
OF RALEIGH, N. C.

I WISH to call attention to what I believe to be a very important contribution to the treatment of fracture of the clavicle, but, at the outset, I desire to disclaim any originality for this splint. In fact, I disavow any credit for it except that of seizing instantly upon a good idea when it was presented to me. The method in question was called to my attention in 1917 by Dr. L. J. Arnold, of Lillington, N. C., who stated that Dr. John A. Bodine, of New York, now deceased, had commended it to his post-graduate classes. In reply to my inquiry Doctor Bodine wrote as follows:

In re the barrel-stave splint for fracture of the collar-bone, all the information that I have about it is that on a trip to Texas many years ago a doctor in Cameron, Texas, showed me the splint on a small boy, and said it was devised by Doctor Spohn, of Corpus Christi. The lad in Cameron was trying to climb a small tree, and to my surprise he had not dislodged the splint and no bad result followed the effort. We have used it in our clinic on a great number of cases and always with entire satisfaction. We have since had a splint modeled in metal with a sliding central joint, so as to make it fit different widths of chests, but, of course, this takes away one of the attractive features—that the old barrel-stave can be quickly found and applied anywhere in the country. It fulfills all the indications, to my mind, with the exception of a tendency of the shoulder to fall downward, so that we have not used it in grown people with heavy muscular or fat shoulders. It has never been written up and never been published, so far as I know, and I think it would be a good thing for you to make it better known.

A letter to Doctor Spohn received no answer.

To apply this barrel-stave splint to a fractured clavicle, the centre of the stave is found, and this should be placed over the centre of the patient's manubrium, at the suprasternal notch. The stave is then sawed off at each end to fit just inside the head of each humerus while the shoulders are drawn backward. One inch from each end a nail is driven into, but not through, the splint. The splint is then padded with cotton, retained by a bandage, and placed in the position as first measured, the concave surface being next to the chest. While the splint is held in place and the shoulders kept firmly back, bandages are tied to the nails, carried under each axilla, and crossed on the back in the figure-of-eight fashion; as many turns are made and the stave is drawn as tightly as necessary. If there is a tendency of the splint to turn or to slip, adhesive plaster may be applied to reinforce the bandage, but it is rarely needed. If the patient is a heavy, muscular subject, the arm is put into a sling.

The appealing quality of this dressing is its comfort. The patient may use his hands and forearms at will without disturbing the fragments, and he is relieved of the distress which the older dressings give. The Velpeau,

* Remarks before the Medical Society of the State of North Carolina, April 15, 1919.



FIG. 1.—Front view—padding purposely omitted from splint.

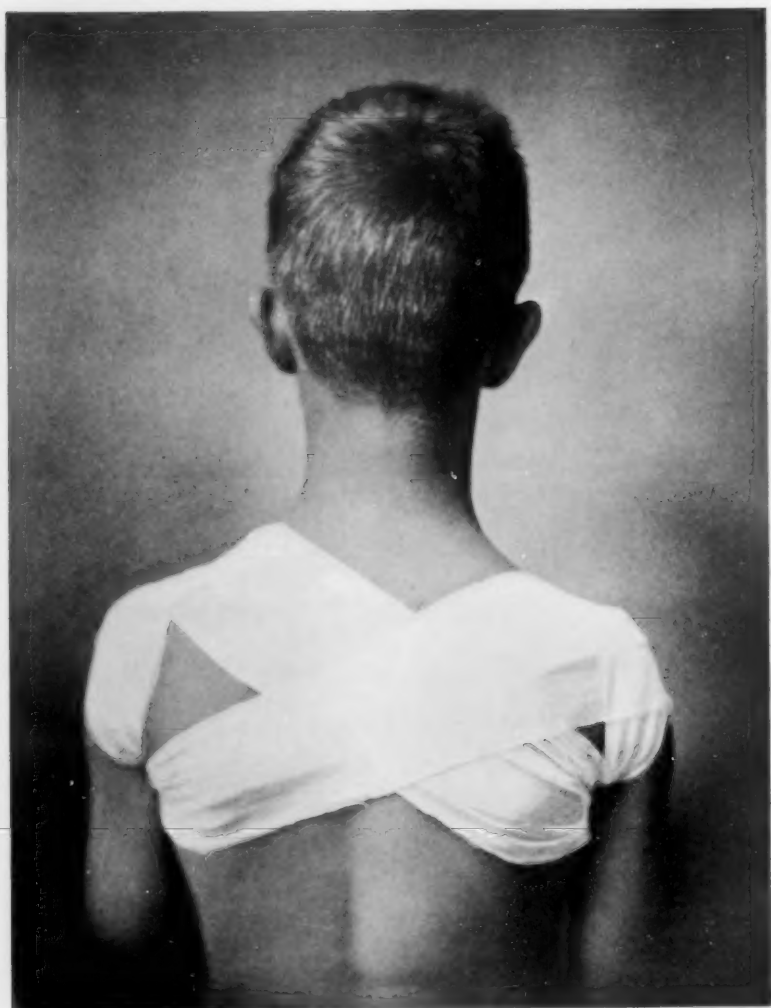


FIG. 2.—Back view—showing figure-of-eight bandage.

SPLINT IN FRACTURE OF THE CLAVICLE

Desault, and Sayre methods are, to say the least, very uncomfortable, while they are, without doubt, difficult to apply and still more difficult to retain. I have treated six personal cases with the barrel-stave; three more have been treated by one of my associates, and several cases by different colleagues. Invariably we have been pleased with the splint and satisfied with the results. One of my cases, a college athlete who did not take the trouble to wear a sling, was injured in December and went back into the pitcher's box in March. A blacksmith from a distant town, who returned home immediately after the first dressing, found that it was slipping. He was not satisfied and, being a good mechanic, went to his shop, fashioned two baby carriage springs, put one in front and the other behind, joining them at each shoulder by a small iron band. The adjustment was perfect and the final result all that could be desired. This suggests that two splints may be used, or that other material will suffice. But the barrel-stave you have with you always.

Undoubtedly the prevailing methods of treating a fractured collar-bone have not given good results, perfect adjustment, or abundant satisfaction to any one of us. Until I came upon the barrel-stave method I had looked in vain for some plan by which a broken collar-bone could be held in place and yet give no discomfort to the patient. I am compelled to say that there has been a disposition to follow teachers and text-books too slavishly, and that certain principles supposed to be vital in the matter do not exist at all. For instance, we have been told that the deformity in fracture of the clavicle is produced "by the action of the powerful muscles attached to the scapula." But you will find that it is due not so much to the pull of the muscles as it is to the dropping downward and inward of the shoulder by its own weight. Dowden,¹ of Edinburgh, has directed especial emphasis against the text-book descriptions of the pulling of groups of muscles as the essential cause of displacement in some fractures. He considers force as the factor in displacement, and criticises unfavorably attempts to put up fractures in special dressings whereby it is hoped to obtain the benefit of muscular pull or to neutralize the effect of muscular action.

This comment applies with singular fitness to fracture of the clavicle. We know that the proper position of the girdle of the upper extremity is obtained by throwing the shoulders backward, and not by elevating them. Indeed, any attempt to elevate the shoulder will result in an exaggerated position, and will actually push the fragments out of line when the clavicle is fractured. Yet in the usual dressings advised for this injury the chief object seems to be elevation of the shoulder. The real problem is to throw the shoulders back and keep them there—a procedure which securely replaces the broken ends. The barrel-stave does this and nothing more.

I ask attention to this simple method of handling a common injury, with the expectation that, unless you have been better pleased than I have with the older, more complicated, and more uncomfortable dressings, you will adopt the use of the barrel-stave splint with much pleasure and satisfaction.

¹ Edinburgh Med. Jour., vol. xxi, No. 6.

PHASES OF WAR SURGERY: BONE TRANSPLANTS FROM THE TIBIA TO THE LOWER JAW FOR LOSS OF SUBSTANCE *

By CHARLES A. POWERS, M.D.

OF DENVER, COLO.

LIEUTENANT COLONEL M.B.C., U.S. ARMY

It is with much hesitation that the writer presents such a small series of cases. His only excuse must lie in the fact that each case was very carefully studied and followed, and, further, that large series are not yet available. In 1916 and 1917 the writer did 11 of these operations at the American Ambulance Hospital of Paris (militarized July, 1917, as the American R. C. Military Hospital No. 1. A. E. F.). An illustrative case is the following:

CASE I.—B. l'André, twenty-three years; French, 152d Regiment Infantry. Wounded in action August 15, 1915, at Sondemar in Alsace by fragments of high explosive shell. Multiple injuries, including shatter of right portion of lower jaw and compound comminuted fracture of skull in frontal region. Ordinary management, patient passing from one French hospital to another. Hospitalized at Toulouse for one year. Admitted to American Ambulance Hospital of Paris April 11, 1917, with all wounds healed. (Patient has had no symptoms from skull fracture; brain pulsation is felt.)

There was pseudarthrosis of the right side of the body of the lower jaw, with apparently considerable loss of substance. Heavy, dense scar tissue on right side of face in this region. Widest possible preliminary removal of this cicatrix.

July 16, 1917. Bone transplant.¹ (On the preceding day dental splints had been applied by the efficient dental department of the hospital, and "open-bite" supports applied in the usual way.) The entire region of lost bone was a dense mass of hard cicatricial tissue, despite the preliminary attempt at excision of the scar. This cicatricial tissue was removed as much as possible, great care being taken to avoid opening the oral cavity. Posterior fragment exposed, it being much drawn in by the pterygoid muscles. Very careful dissection of the soft parts from the bone, especially at the end of the fragment where it was solidly fibrous and densely adherent. Anterior fragment exposed and cleared. Loss of substance was found to be something over two inches. Seat made in posterior fragment by Albee saw and a chisel, care being taken to go well down into bleeding bone. Seat made in anterior fragment, but this difficult because of dense eburnation of bone. Cultures (proving negative) taken from each cut in bone. Dry wound secured. Fragment of suitable length taken from tibia by twin saw, the periosteum

* Read before the American Surgical Association, June 18, 1919.

¹ The operation here detailed was the type adopted in all of the cases.



FIG. 1.—B-1. Showing transplant nine months after operation.



FIG. 2.—B-t. Showing transplant eight months after operation. Black specks represent tiny foreign bodies diffused in soft tissue.



FIG. 3.—Bai-t. Showing transplant eight months after operation.



FIG. 4.—Transplants of tibia to lower jaw. Viewed from left to right, the first case was a failure, the other two cases were successful.



FIG. 5.—Transplants of tibia to lower jaw. Viewed from left to right, the first four cases were successful, the fifth case a probable success. The soldier in the middle had transplants to both sides of jaw and at time of taking of picture was still in "open bite." (Photograph taken April 3, 1918.)

BONE TRANSPLANTS FROM TIBIA TO LOWER JAW

being so raised laterally as to drop over sides of fragment. Ends of graft beveled so that the periosteum dropped over these obliquely cut ends. Transplant applied to lower jaw, held in place by forceps, and the soft tissues carefully sewn over it by interrupted sutures of fine black silk. The sutured soft parts held the fragment in place, but the fragment did not "wedge" into the two portions of the lower jaw proper. Covering of transplant difficult in this case because of the density of cicatricial tissue. Subcuticular stitch to skin without drainage. Very large, firm, carefully applied dressing, with heavy crinoline support. Leg put up in plaster-of-Paris for six weeks.² Each subsequent dressing done with the detail of an aseptic operation. Smooth course. Inter-dental supports and splints removed at the end of three months and solid union found throughout. Patient re-examined from time to time for one year from date of operation.³ The union held. Function of jaw practically perfect. (Fig. 1. X-ray taken nine months after operation.)

CASE II.—Brunet, aged twenty-two years; wounded September 25, 1915. Had been in several French hospitals. Entered the American Ambulance Hospital at Neuilly June 13, 1917, with double pseudarthrosis. Considerable loss of bone on both right and left sides of lower jaw in front of angles. Loose middle fragment very freely movable. Operation on left side November 6, 1917, with "open-bite" inter-dental splint fixation of fragments. No infection. Inter-dental splint not disturbed, and right side subjected to similar operation ten weeks later. Perfectly smooth course. Fixation maintained for six months from date of first operation, when all inter-dental splints were removed and firm consolidation found on both sides of the jaw. On letting the jaws together at the end of six months, no ankylosis was present on either side. In order to get perfect approximation of the dental arcades, it was necessary to extract one posterior right upper molar—a matter of slight surgical importance. This man was kept under observation for eight months after the first operation, or until the American wounded filled the hospital in the summer of 1918. (See Fig. 5. Soldier in middle of picture.)

Results.—Eleven transplants made on ten patients, this last related case being double. In these 11 operations there were three infections, each infected case being followed by loss of the graft. Results in the 11 cases: Seven cases, or 63+ per cent., of complete successes; 3, or 27+ per cent., of complete failures; and 1 case, 9 per cent., undetermined, but a probable success when last seen in June, 1918. (The conditions of success embraced absolutely solid consolidation, excellent dental approximation,⁴ good mastication of not too hard food, and a good speaking voice.)

If, however, we divide these 11 cases into two classes, by years, we find

² The leg gave no trouble in any case.

³ Fig. 5. Second case from left in picture.

⁴ Naturally, suitable artificial teeth were put in.

five operations done in 1916 with 2 complete successes, or 40 per cent., and 3 complete failures, or 60 per cent.; while the six operations done in 1917 (added experience) show 5 full successes, 83 per cent., and 1 undetermined result, but probable success, 17 per cent.

Remarks.—The war has brought greatly increased experience in transplants to the lower jaw, yet there is not unanimity of opinion as to form of operation, or, indeed, as to the real value of any procedure. Leriche (1918, "M. & S. Therapy," 4th vol.) says: "We believe we are justified in concluding that at the present moment the results of bone grafting in mandibular pseudoarthrosis are not demonstrated." As Sébilleau has said, 'they are encouraging, no more.' Morestin told the writer that he used cartilage and inserted it chiefly for its æsthetic value. Imbert and Réal (1917) agree with Sébilleau. Hull, in the second edition of his excellent work, "Surgery in War," 1918, says: "All engaged in this work are unanimous on one point, that it cannot be safely undertaken in less than six months from the date of the injury. As it takes another six months to estimate truly the results, the lack of series of published cases is easily understood." In June, 1918, a surgeon from the British centre at Sidcup told the writer that they were doing some of these cases with the closed-bite under rectal anæsthesia. They had not at that time formulated an opinion as to the value of any particular operation.

It goes without saying that very much time will be needed to determine the ultimate fate of any bone transplants. Further experience will be required to demonstrate the relative value of different procedures, but the writer is convinced that something should be attempted for the relief of these seriously disabled people.

FOREIGN BODIES ARRESTED IN THE DUODENUM

By WILLIAM FISHER, M.D.

OF TOLEDO, OHIO

SURGEON TO ST. VINCENT'S HOSPITAL

THE polyphagia of the professional charlatan, the bulimia of the insane, the prehensile and deglutitious characteristics of infants, and the accidental ingestion of foreign bodies by normal adults have been and are from time immemorial a part of the cycle of human events. Surgical literature is voluminous from the earliest times with the history of many and curious examples of the ingestion of foreign bodies; with organs involved in their transit or retention; with the phenomena attendant upon nature's efforts to expel them; and with records of fatal results. From the very triteness of the subject our interest is awakened only when there is retention of the foreign body and the effect "per se" upon the organ involved and the life of the patient.

Of these ingested foreign bodies case reports show the stomach suffers most, ileocaecal next, and finally involvement of the rectum. Considering the anatomical position of duodenum with the duodenojejunal flexure, with its marked angulation, often the seat of partial occlusion, one can but wonder why it so often escapes the lodgement and effects of foreign bodies. Surgical literature teems with reports of gastrotomies, rarely so with duodenotomies. In 1502 the first known gastrotomy was successfully performed by Florian Mathias, of Bradenberg, for the removal of a knife nine inches long, which had lodged in the stomach seven weeks and two days. Patient recovered. The second recorded case by Schwaben in 1635 at Koenigsberg, who by gastrotomy extracted a knife ten inches long. Patient recovered.

Passing to more recent times, Winslow, 1918, in reporting a successful gastrotomy remarks: "The grand total of foreign bodies in her stomach and intestines on admission, as shown by the X-ray and by removal, was 1300, most of them sharp-pointed objects that were liable to perforate the walls of the viscera. This is the largest number of individual objects that has ever been removed from the stomach of the living human being." How many of these sharp bodies passing through the stomach would have found lodgement in duodenum is problematic. That many passed the duodenum is demonstrable in the X-ray picture. Evidently the duodenum seems to be somewhat immune as a reservoir for foreign bodies. This observation is tenable owing to the meagreness of the literature of this subject.

Houston mentions a maniac who swallowed a rusty iron spoon, eleven inches long. Fatal peritonitis ensued and the spoon was found impacted in the last acute turn of duodenum. Perkins reports an open safety-pin swallowed by a fourteen-months-old child. The ray showed the bar of the safety catch passed into the duodenum, while the sharp end was embedded in

the gastric mucous membrane of the pylorus. Operator W. G. Crump, technic not given. Patient recovered. Gerster cites a case reported by Melchoir:

A nurse, aged twenty-four years, was admitted to Kuttner's Clinic, in Breslau. She had swallowed a paper of needles five years before. Ever since then, more or less digestive trouble. For the past fourteen days continuous pain in the right side of the duodenum, with tenderness a finger's breadth to one side of the umbilicus. Antero-posterior X-rays showed four vertically situated needles in the descending part of the duodenum. Abdomen opened through a median incision, but nothing could be felt. Relying entirely upon the X-ray findings, the duodenum was mobilized, now the upper ends of two needles could be felt in the descending part. Longitudinal incision of the duodenum permitted extraction of these. After closure of the intestine, two more needles could be felt close to the pylorus. By pressing upon the duodenal wall the points of these emerged through it and were pulled out. The small puncture wounds were closed over with sutures. Gastro-enterostomy was then established to prevent too much strain upon the duodenal sutures.

Review of the literature revealed that the point of transition between the vertical and third part of the duodenum was the site at which foreign bodies most frequently became lodged. In the hope of stimulating inquiries concerning this subject, I have succeeded in collecting and collaborating the following three cases. These represent the entire number of duodenotomies performed in this district for the past thirty years:

CASE I.—Rudolph G., aged three years, came in June 10, 1918, referred by Dr. R. L. Bidwell, with a history of having swallowed a hairpin three days previously. At that time it was not clear whether the pin was in the stomach or the transverse colon.

Later, X-ray examination by H. W. Dachtler showed the pin to have become fixed in the third portion of duodenum, one end of the sharp point having become bent at an angle and penetrating the mucous coat of duodenum.

Operation.—Duodenotomy, July 12, 1918, operator R. L. Bidwell. Under gas-oxygen anæsthesia, median incision was made. Incision one-half inch in duodenum and pin extracted. Duodenum closed with two layers linen. Recovery uneventful.

CASE II.—Gains A., aged fifteen and one-half months, was referred by Dr. L. A. Brewer on March 26, 1914, with a history of having swallowed a large metal instrument about the size and shape of a sewing machine screw driver one week previously. On March 25th, the day before the examination, the child had begun vomiting, which had alarmed the parents. On X-ray examination by H. W. Dachtler the foreign body was seen lodged in the duodenum with the point upward. It proved to have a sharp point, being known to the trade as a basting thread remover.

Operation.—Duodenotomy March 26, 1914; operator, L. A. Brewer. Under ether anæsthesia right rectus incision was made. The foreign body was readily palpated in third portion of duodenum, the sharp point having penetrated the posterior bowel wall. Having withdrawn

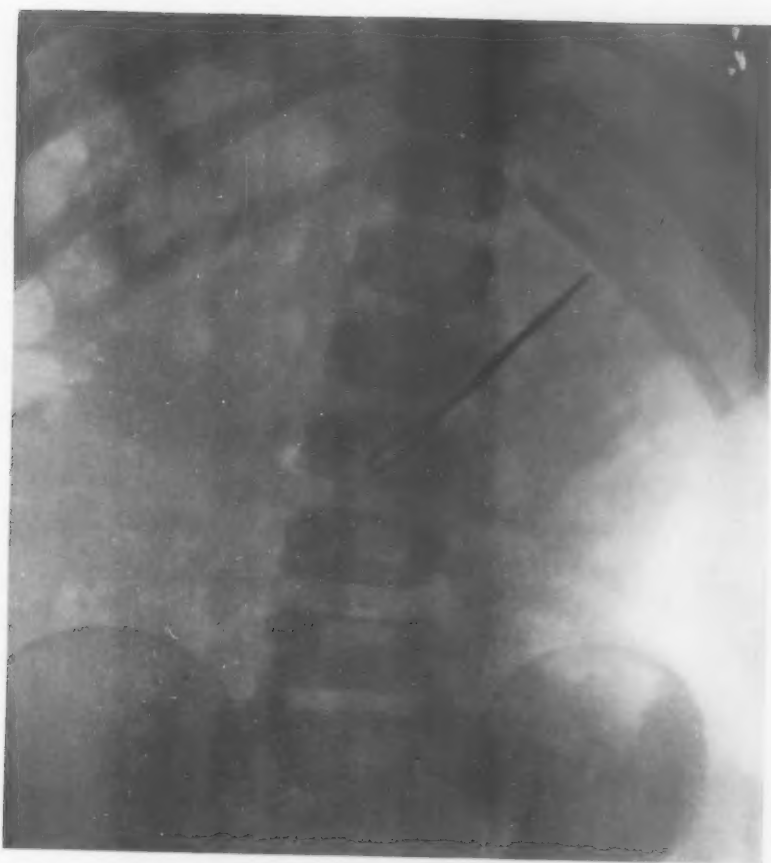


FIG. 1.—(Case I.) "Hair pin" fixed in third portion of duodenum, one end of sharp point having become bent at an angle penetrating the mucous coat of duodenum.

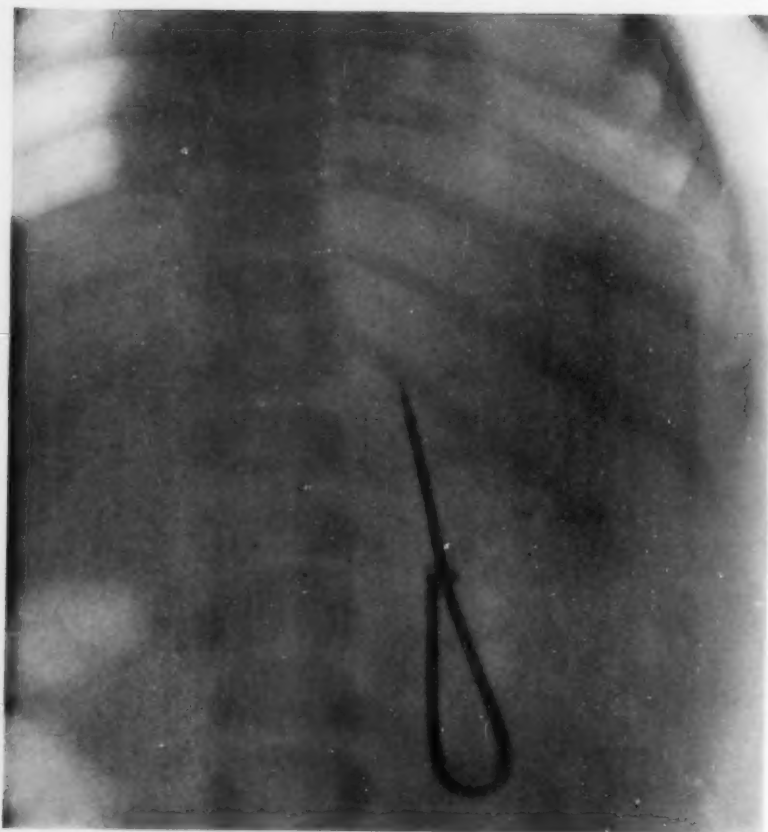


FIG. 2.—(Case II.) "Basting thread remover" fixed in third portion of duodenum, the sharp point having penetrated its posterior wall.

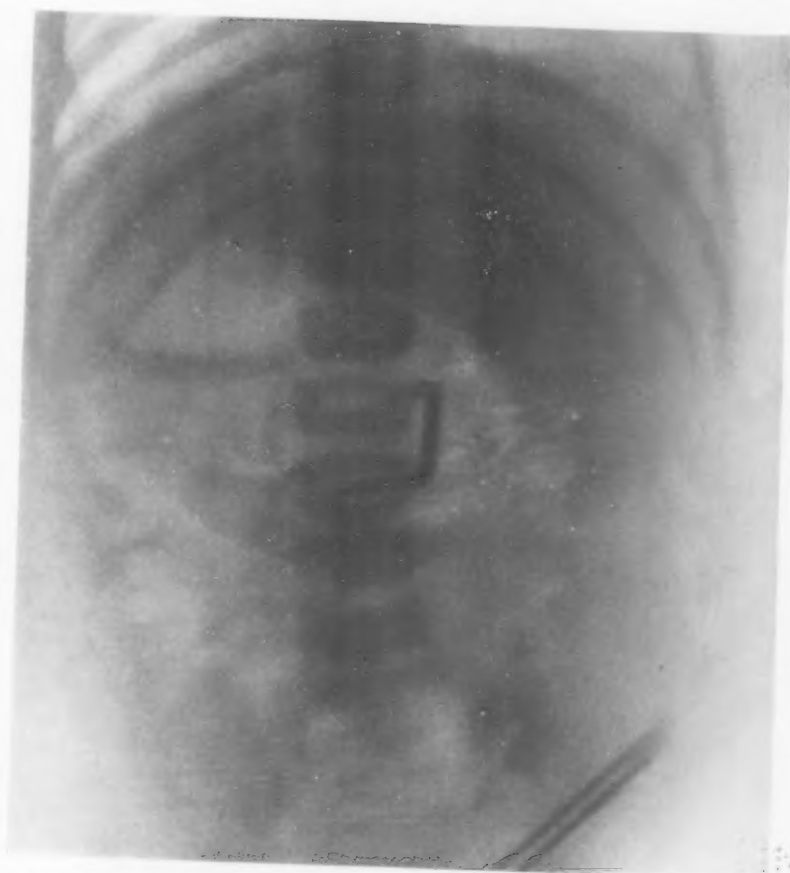


FIG. 3.—(Case III.) "Beauty pin" fixed along the inner edge of the vertical portion of duodenum, the sharp point having penetrated the bowel.

100-100-100
100-100-100
100-100-100
100-100-100
100-100-100

FOREIGN BODIES ARRESTED IN THE DUODENUM

the "basting thread remover" from its attachment, it was pushed through the anterior wall of duodenum, the opening enlarged one inch in the longitudinal axis of the duodenum to allow its extraction. Czerny closure with catgut and running linen Lembert suture. Recovery uneventful.

CASE III.—Florence O., aged thirteen months, first seen September 3, 1918, with a history of having swallowed a "beauty" pin about seven-eighths of an inch long, about two hours previously. On fluoroscopic examination by H. W. Dachtler this was found to be in the stomach. On September 5th another examination showed the pin to be in the second portion of the duodenum in a diagonal position. The child was examined at intervals until September 12, when a small barium meal was given, as at that time the body of the pin was vertical and the pin transverse, and I was of the opinion that the pin had punctured the bowel and that the body of the pin was along the inner edge of the vertical portion of the duodenum. This was definitely proven by the barium meal. Operation was refused at this time and the child was seen on October 8th, on November 6th, and again on November 23rd. At each of these examinations the pin was found in the same location. Operation was then consented to and a last examination was made December 7, 1918, just before operation, to make certain that the pin had not become dislodged.

The plate showed the pin in the position in which it finally came to rest, with the point penetrating the gut completely, so that the body of the pin was in contact with the inside of the duodenum along its median aspect. The pin had attempted to leave the stomach point first in an almost straight position, but the point became engaged with the wall of the duodenum which was too small to allow the hinged portion to pass down and close the pin. It was only as the point penetrated the wall that the body of the pin worked down, due to peristalsis, and it came to rest when the pin was entirely through the gut with the hinge in contact with its inner wall. In this position food passing through the duodenum failed to move it.

Operation.—Duodenotomy, December 10, 1918; operator, Wm. H. Fisher. Under gas anæsthesia, right rectus incision was made. On opening the abdomen the site of pin was readily located, guided by the circumscribed adhesive peritonitis which involved the gall-bladder area. These were separated and the duodenum opened longitudinally one-half inch; pin extracted and the bowel closed with Czerny catgut suture and Lembert running linen. Recovery uneventful, primary union, discharged ninth day.

"ENURESIS" OF ADULTS; HYPERTONIC BLADDER *

BY LEOPOLD BRAHDY, M.D.

OF NEW YORK

LIEUTENANT M.C., U.S.N.R.F.

WHEN patients have frequency of urination and nocturnal incontinence since birth, they are usually considered to have a neurosis which will "wear off in time." This diagnosis and prognosis is not correct in most cases. There are three groups of congenital bladder disturbance which should be clearly differentiated. They differ in symptoms, etiology and prognosis.

First.—The continuous dribbling of urine. This form is usually accompanied by obvious organic defects of the genito-urinary organs or spinal cord.

Second.—The persistence of the infantile unconscious reflex. When the bladder has become full urination takes place. The patient is not conscious of a full bladder or of a desire to urinate till after the bladder begins to empty. This condition seldom persists beyond puberty.

Third.—The occurrence of an urgent desire to urinate when the bladder contains only 150 c.c. or less of urine. Involuntary urination takes place if the patient does not void within a few minutes after onset of the desire. This form persists into adult life.

It is with this third group that this paper is concerned. The cases in this group are distinct from the normal incontinence of infants. The condition is known as congenital enuresis but the name is a misnomer. Patients sometimes do not wet the bed or their clothes, though they give a history of having done so in childhood. Considering the data presented below, it is believed a better name would be "congenital hypertonic bladder." I have examined fifty cases in a period of six months at a station where recruits come in at the rate of four hundred a week. It is probable that this number represents less than one-half of the cases, as many are given a medical discharge soon after their arrival. The histories and findings in all of these men are strikingly similar.

CASE I.—G., nineteen years of age. Father is well and strong. Mother has "weak heart" and is "nervous." One brother well. One sister (fourteen years old) has had a similar condition all her life. She usually wets her bed. Patient states he has had "bladder trouble" all his life. No remissions. He gets up three or four times a night. During the day he has marked urgency every 45 to 60 minutes. No burning of urination; very powerful urinary stream.

Three years ago was treated with belladonna for five months. No effect. He has constant pain in the lumbar region, often sufficient to

* This article was written when the author was Director of the Genito-Urinary Subdivision of the U. S. Naval Training Station, Hampton Roads, Va. Permission to publish granted by the Navy Department.

"ENURESIS" OF ADULTS

incapacitate him from all work. He gets tired very easily and is always sleepy. Appetite fair. Feels thirsty very often; drinks seven or eight glasses of water a day.

Physical Examination.—Thyroid slightly enlarged. Tonsils small and buried. Soft systolic murmur at apex. Pulse 80. Knee-jerks and cremasteric reflexes normal. Vertebral column: second lumbar spine cannot be felt. Tenth and twelfth dorsal vertebrae are very prominent. Tenderness over twelfth dorsal and first lumbar vertebrae, most marked over first lumbar vertebra.

The following is a record of the frequency of his urination:

Specimen	Time	Amount	Specific Gravity
1 and 2	9.10	290	1018
3	10.30	110	1005
4	11.10	345	1005
5	11.45	390	1004
12.00, Lunch.			
6	1.15	100	1016
7	1.55	165	1012
8	3.00	250	1006
9	4.20	70	1019
5.00, Supper.			
10	6.50	155	1021
11	8.10	145	1015
12	9.30	160	1007
9.30, to bed—Patient awoke four times. He did not wet the bed.			
13	11.30	180	1007
14	12.30	165	1008
15	3.30	190	1014
16	5.30	145	1015

Cystoscopy.—Bladder holds 480 c.c. Slight trabeculation which becomes more prominent when there is only 300 c.c. in the bladder. Trabeculation confined to the floor and posterior wall. April 10, 1919: Urine pale, alkaline; specific gravity 1.019; slight trace of albumen; sugar negative; microscopic, few epithelial cells. April 14 and 20, 1919, acid and no albumen.

Stool.—No hookworm.

X-ray of Lumbosacral Spine.—All transverse processes, pedicles, laminae and spinous processes are normal.

Summary of Case.—History.—(a) Frequency and urgency; small amount of urine voided each time. (b) Congenital onset. (c) No remissions. (d) Weakness of mother. (e) Similar condition in a sister. (f) Pain in lumbar region. (g) Easy fatigue and drowsiness.

Examination.—(h) Tenderness of lumbar spine. (i) Trabeculated bladder. (j) Bladder capacity tested by injection is 480 c.c.

Examination of the table shows that when the bladder was filling quickly the patient voided relatively large amounts (345 c.c. in 40 minutes and 390 in 35 minutes). This large amount is more nearly the bladder capacity). Usually small amounts are voided.

CASE II.—W., twenty-two years old. Male. Father had similar trouble till he was sixteen years old; otherwise was strong and healthy. Mother died twenty years ago of tuberculosis. No brothers or sisters.

Had trouble with urine all his life. Wet bed every night till twelve to thirteen years of age. Now gets up four or five times a night. During the day he holds urine about two hours; at end of two hours he has sudden urgent desire to urinate. The urine is voided in a forceful and large stream. If he tries to hold his urine involuntary urination takes place in a few minutes. No burning or pain on urination, but a sense of marked relief.

The patient complains of easy fatigue and drowsiness in the afternoon. His appetite is good and there is no unusual thirst. Occasional frontal headaches. Constant pain in the lumbar region made worse on bending forward.

Physical Examination.—No hair on chest. Beard sparse. Pubic hair, female distribution. Thyroid slightly enlarged. Pulse 94. No vertebral tenderness. Cremasteric reflexes and knee-jerks very lively. Long foreskin; left varicocele.

Cystoscopy.—Bladder holds 300 c.c. of urine. Marked trabeculation of whole bladder. Otherwise normal.

Urinalysis.—Color amber. Reaction alkaline. Specific gravity, 1.024; albumen negative; sugar negative.

Microscopic Examination.—Occasional pus cell.

Stool.—No hookworm.

One week after cystoscopy, I filled the bladder with 350 c.c. of boric acid solution. No more would flow in under a pressure of four feet of water. There was a trembling of the lower extremities with marked rigidity of the lower abdomen. The fluid was retained for five minutes. Then the desire to urinate became imperative.

Comment.—This case presents all the symptoms of the first case except tenderness of the vertebral column, and it is the only case in which this tenderness was absent. The reflex spasticity of the muscles of the legs and abdomen from the full bladder is of interest. It was present in four cases. The phenomenon is probably a clue to the pathology of this condition. A partially full bladder sends sufficient stimuli to the hypersensitive lumbosacral cord to cause muscle spasm.

CASE III.—McA., male, white, eighteen years of age. Father died of accident. Mother weak and has "fainting spells." One sister, four years old. Condition of her bladder control unknown. Patient gets up five and six times a night. During the day he has marked urgency every one-half to three-quarters hour. Till four years ago, wet bed every night since infancy. Suprapubic pain from a few minutes before to a few minutes after urination. Appetite good. No unusual thirst. "Short-winded" and gets constant pain in the lower dorsal region more marked on bending over.

Physical Examination.—General appearance that of a Frolich hypopituitary type. Voice high-pitched. Alert and intelligent. Skin smooth,

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cheeks pink. Thyroid slightly enlarged. Cranium small. Tonsils large. Heart and lungs normal. Pulse 104. Extremities rounded and firm, hips broad, breasts developed. Abdomen slightly protuberant, face and body free of hair except for a very few pubic hairs. Pad of pudental fat, penis small; scrotum small, testicles normal. Cremasteric, kneejerks and light reflexes very lively. Bladder capacity 400 c.c. This amount caused a very urgent desire to urinate. Cystoscopy not done because after meatotomy penile urethra was too narrow for a No. 24 sound. Urine pale, alkaline, albumen negative, sugar negative; specific gravity 1.018.

Microscopic Examination.—Epithelial débris.

Stool.—Positive for hookworm two weeks ago; treated; none present now.

The following is a record of his twenty-four-hour urine excretion:

Number	Time	Amount	Specific Gravity
1	8.50 P.M.	115 c.c.	1.021
2 Awoke	10.25 P.M.	65	1.026
3 Awoke	12.05 A.M.	88	1.021
4 Awoke	1.15 A.M.	86	1.019
5 Awoke	3.10 A.M.	98	1.018
6 Awoke	5.50 A.M.	110	1.018
7 Awoke	6.50 A.M.	170	1.010
8 Awoke	9.55 A.M.	35	1.020
9 Awoke	11.00 A.M.	87	1.024
DINNER.			
10	12.20 P.M.	50	1.022
11	1.15 P.M.	130	1.002
12	1.35 P.M.	45	1.025
13	4.55 P.M.	65	1.126
SUPPER.			
14	5.40 P.M.	110	1.010
15	6.35 P.M.	130	1.010
16	7.05 P.M.	67	1.008

This case of hypopituitarism is presented because it has often seemed that many patients had a more youthful appearance, a higher pitched voice, a scantier development of the hirsutes than other recruits of the same age. These signs were too slight to note in individual cases, but collectively they gave that impression. There is one other case of hypopituitarism in the series. It seems that the study of pituitary function in these cases may yield valuable data.

CASE IV.—McM., nineteen years of age. Father was healthy. Died of an accident. Mother has "heart trouble," is weak and nervous. Three brothers, none of whom have similar condition. He has wet his bed every night all his life. Sleeps soundly. During the day he holds his urine one and a half to two hours, then has marked urgency. Appetite good. Drinks five glasses of water each day. Has constant lumbar pains. Gets tired easily. Feels sleepy in the afternoons. He had a remission a few years ago. For three months he "wet only sometimes,

not every night, but almost every night," and held his urine longer during the day. During this time he was taking "Swamp root and something else." He stopped treatment because it didn't cure him altogether.

Physical Examination.—No important findings except tenderness over the third lumbar vertebra.

Cystoscopy.—Bladder holds 450 c.c. Normal except for fairly well-marked trabeculation on posterior and lateral walls.

Urine amber, alkaline; specific gravity, 1.020; albumen, negative; sugar, negative.

Microscopic examination.—Occasional leucocyte.

Comment.—This man is the only one of the thirty-six who gave a history of a remission, which he believed due to medication; though this man slept soundly all night the drowsiness and easy fatigue were more marked than in most cases. One patient had trained himself by abstaining from fluid after 3 P.M. to sleep without getting up or wetting the bed for six to seven hours; nevertheless, he complained of drowsiness and easy fatigue, as did the others.

CASE V.—D. J., nineteen years of age. Family history, negative. Well till six years ago, when he had epidemic cerebrospinal meningitis. Intraspinal serum treatment. Immediately following he had nocturnal enuresis which has persisted since. Wets the bed every night. During the day he urinates every half hour. He has pain in the suprapubic region immediately before urination. Pain in the lumbar region if he tries to hold his urine. Marked urgency. No history of easy fatigue or drowsiness.

Physical Examination.—Marked tenderness over fourth lumbar vertebra; otherwise negative.

Cystoscopy.—Bladder capacity 350 c.c. Bladder walls markedly trabeculated.

Urine Examination.—Amber, alkaline; specific gravity, 1.021; albumen negative.

Microscopic Examination.—Rare white blood-cells and epithelial cell.

This is the only patient in whom the onset of the disease was in later life. The case is similar to those of congenital origin except for the absence of family history and of the rapid fatigue and drowsiness.

CASE VI.—Age, twenty-five years. Fourteen days in the Navy. Both parents healthy. No similar condition in other members of the family. Was perfectly well before enlistment. Has slept in hammock nine nights. Wet hammock the last five nights. No bladder disturbance during the day. Has some lumbar pain.

Physical Examination.—Negative.

Patient slept on cot two nights, during which he has no enuresis. Then slept in hammock again. Wet hammock several nights for the next two weeks. The three weeks following, no enuresis.

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This case is presented only as a contrast to those included in the above series. Some of these cases of acquired incontinence have frequency during the day and occasionally are more persistent, nevertheless the distinction from the cases in this series is obvious. The onset is recent, the family history is negative, there is no tenderness of the vertebral column and no drowsiness or easy fatigue. When these acquired incontinence cases have diurnal frequency, urgency is absent or slight.

The following is a tabulation of the signs and symptoms in 50 cases:

	Cases	Per cent. of Cases
Symptoms since infancy	49	90
"Weakness" and nervousness in the mother	41	82
Other members of the immediate family have similar conditions (7 cases females)	36	72
Wet bed	30	60
Get up at night (no bed wetting)	16	32
Lumbar pain	47	94
Tenderness of lumbosacral spine	49	98
Drowsiness and easy fatigue	49	98
Frontal headache	25	50
Cystoscopy was done in	26	
Trabeculated bladder found in	23	89

Five cases had X-ray of the lumbosacral spine by Dr. C. C. Hugger. He reported negative findings in all five cases.

Wassermann-Noguchi reaction was done in six cases. All six reported negative by Dr. C. F. Holtegal.

Comment.—All these cases are in males. Several patients give a history of a similar condition in a sister. Considering that the men often do not know of the existence of such a condition in the female members of the family, it is probable that the condition is not uncommon in women.

These cases illustrate a type of bladder disturbance probably due to a congenital hypertonicity of the bladder. The difference between the amount of urine usually voided and the amount of fluid which can be injected, the trabeculated bladder, the powerful urinary stream, indicate increased tonus. The lumbar pain, the tenderness of the vertebral column, the frequency and urgency in the absence of any unusual stimulus, the occasional spasm of the abdominal and leg muscles on filling the bladder, indicate hyper-sensitive as well as hyperactive cord centres.

The cases are characterized by an urgent desire to urinate when the bladder contains from 100 c.c. to 150 c.c. of urine. Involuntary urination takes place if this desire is not acted upon. The physical bladder capacity is only occasionally markedly diminished. The "physiological capacity," that is, the amount the bladder will hold before the bladder contraction reflex takes place, is always less than half the normal. Remissions occur but are rare, of short duration, and not complete.

There is commonly a history of similar condition among other members

of the immediate family. A history of "weakness" and "nervousness" in the mother occurred in 82 per cent. of cases.

Patients are subject to easy fatigue and become drowsy in the late afternoon. With one exception they were mentally normal.

The lumbar pain is often made very severe by any physical work.

Cases present the following physical findings: Tenderness of the lower lumbar and upper sacral vertebræ is almost constant. Occasionally there is evidence of increased tone of the muscle of the lower abdomen.

Cystoscopy gives a fairly constant picture of trabeculated bladder. The trabeculation is found most often posterior to the interureteric ridge and posteriolateral wall; in cases with marked frequency the whole bladder is trabeculated. There was no cystitis. Pelzman independently described this cystoscopic picture, having found it in a series of cases of "enuresis" at Camp Meade. He also noted the constant history of congenital onset and the history of "enuresis" in other members of the family. I believe that is the first description of the condition.

X-rays of the spine and routine urinary examinations were negative.

Treatment.—Many cases give a history of prolonged belladonna treatment without benefit. I have treated three of these cases by daily distention of the bladder with 400 c.c. to 600 c.c. of boric acid solution. One patient reports no improvement after three weeks. Two patients doubled the time during which they could hold the urine and held twice the former amount. The urgency was just as marked as before treatment. Methods of treatment should be investigated. The condition is not merely annoying; these men are unfit for military service and are seriously handicapped in any other occupation.

CONCLUSION

There is a clinical syndrome characterized by occurrence in families, congenital onset, frequent voiding of small amounts of urine with marked urgency, easy fatigue and drowsiness, tenderness to percussion of lower lumbar and upper sacral vertebræ and trabeculated bladder.

REFERENCE

- Pelzman, Ivy Albert: A New Cystoscopic Finding in Cases of Enuresis. *The Military Surgeon*, vol. xliv, p. 383, April, 1919.

THE ORGANIZATION AND OPERATION OF AN EVACUATION HOSPITAL *

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DURING the war, ideas change from time to time regarding the organization of an evacuation hospital and the function which it should perform. The necessity of treating wounds early and of performing major surgical operations in the advanced zone demanded a larger staff than had been provided in the tables of organization. With the re-introduction of débridement into military surgery, the evacuation hospital became the most active and important operating centre in the whole chain of hospitals.

Changes in the physical equipment of the evacuation hospital were necessitated by the changes from trench to mobile warfare. An evacuation hospital must be an actively mobile unit. In order not to embarrass transportation, which is not often available to the extent necessary, such a hospital should be under tentage. The bed capacity should not be greater than 500—425 Gold Medal cots and 75 iron beds for fracture cases. Beds are not needed so much as a force of operating surgeons large enough to take care of the wounded, and a transport system which can provide for rapid evacuation.

The so-called evacuation hospital of trench warfare was not strictly speaking an evacuation hospital, for it was immobile, and in many instances where it could have been moved, the time required in taking it down and setting it up was so great, and the amount of transportation needed to move it so large, that it was for all practical purposes immobile. A hospital which by dint of circumstances is so situated that it receives wounded early but is immobile should be designated as an advanced base rather than as an evacuation hospital.

An evacuation hospital of 500 beds can take care of the wounded of a division providing it has 10 operating teams, and can evacuate the wounded frequently enough to provide beds for those being brought in. A hospital of this type must be easily moved. It should be taken down within twelve hours and be set up and receiving wounded in from 8 to 12 hours after reaching the site selected for it. A water supply must be at hand and transportation provided before such a hospital can function. These are the two prime requirements.

A hospital of this type should be under tentage in order to permit of quick movement and to reduce to a minimum the demands upon the transportation system. Such a hospital is much more compact than a barracks hospital, regardless of how well planned such a hospital may be, and how easily the different parts may be knocked down and put together.

* Read before the American Surgical Association, June 17, 1919. Approved for publication by the Surgeon General, U. S. A.

The operating part of an evacuation hospital such as the one now being described should consist of five Bessonneau, Henri or Dickson tents. There should be 20 ward tents for housing the sick and wounded, one shock tent and one tent for the dressing of lightly wounded. In setting up the tents, the idea of reducing to a minimum the amount of littering and of placing the patients being received so that they are operated upon in the order in which they are received, excepting, of course, those who have been so seriously wounded that immediate care is necessary, should always be kept in mind. What we may designate as a linear set up meets the requirements better than any other arrangement we know of.

Advantage of the Linear Set Up.—In this set up, the receiving tent is placed upon the main road or not far from the same. Directly back of this is placed the second tent, in which bandages are changed, smaller dressings applied to facilitate the location of foreign bodies by X-ray examination, and antitetanic serum administered if none has been given previously.

The third tent is devoted to X-ray work. An evacuation hospital should always be provided with two X-ray machines in order that the operating teams should never be delayed because the wounded have had no X-ray examination.

Directly back of the X-ray tent is the pre-operative tent or ward, provided with litter rests. The wounded on the litters are placed upon these rests in the order in which they enter the hospital, with the exception of the seriously wounded, who are taken care of immediately. Back of the pre-operative ward is the operating tent.¹ The advantage of this set up is that there is a continuous litter from the receiving to the operating tent. It is practically impossible to lose track of the wounded, each being taken care of in the order in which he enters. By this arrangement, there is no possibility of a wounded man being forgotten or disregarded for forty-eight hours or more, for he is always under the observation of litter bearers, who feed the operating room, and besides the cases are checked frequently by the surgical chief or one of his assistants. This arrangement permits the surgical chief to operate and besides enables him to maintain supervision of the pre-operative ward, because of its proximity to the operating tent.

On either side of the receiving ward are placed the shock and dressing tents. The sorting of cases is done in the receiving tent. The lightly wounded, who require dressing only, are passed out of the back of the receiving ward to the dressing tent and the badly shocked are taken directly from the receiving to the shock tent. Littering of shock cases is thus reduced to the minimum.

Two to three tents are reserved as occasion demands for non-evacuable cases. These tents are placed directly back of the operating tent and near

¹ A small room built of wood should be placed at middle of side of the operating tent. All sterilizing should be done in this. No open flame should be allowed in the operating tent proper. A wall tent should be set up at the other end of this room, with which it communicates, in which supplies may be prepared and stored.

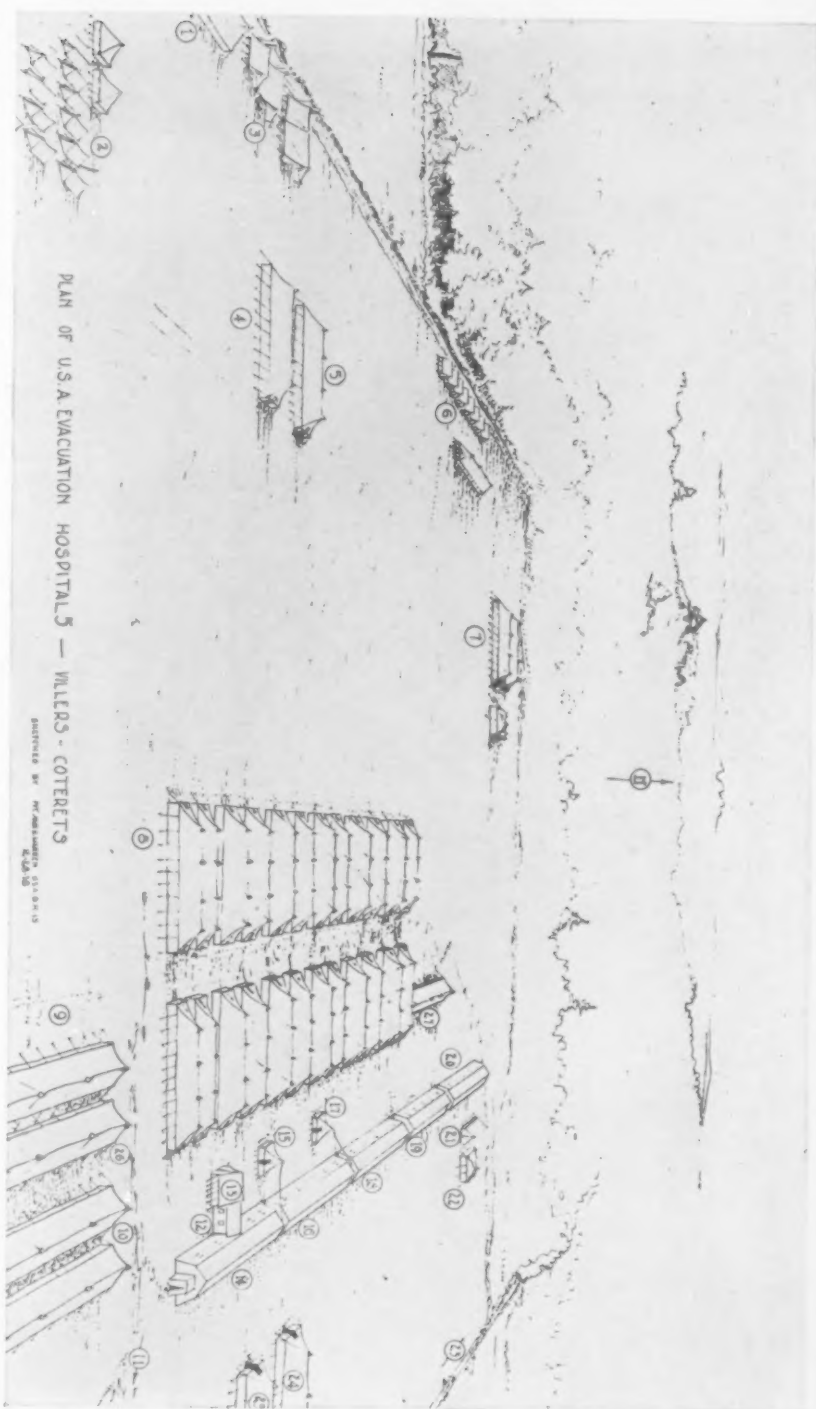


Fig. 1.—Plan of Evacuation Hospital No. 5, Villers-Cotterêts, France, August 29—Sept. 14, 1918. 1, commissary; 2, personnel quarters; 3, kitchens; 4, nurses' mess; 5, officers' mess; 6, officers' quarters; 7, nurses' quarters and recreation tent; 8, surgical wards; 9, non-evacuable wards; 10 and 26, fracture wards; 11, road to evacuation platform; 12, sterilizing room; 13, dressing tent; 14, operating Bessonneau tent; 15, lighting plant; 16, pre-operative Bessonneau tent; 17, X-ray power plant; 18, X-ray Bessonneau tent; 19, 20, receiving wards; 21, headquarters; 22, Red Cross; 23, main highway; 24, quartermaster; 25, medical supplies; 27, shock ward.

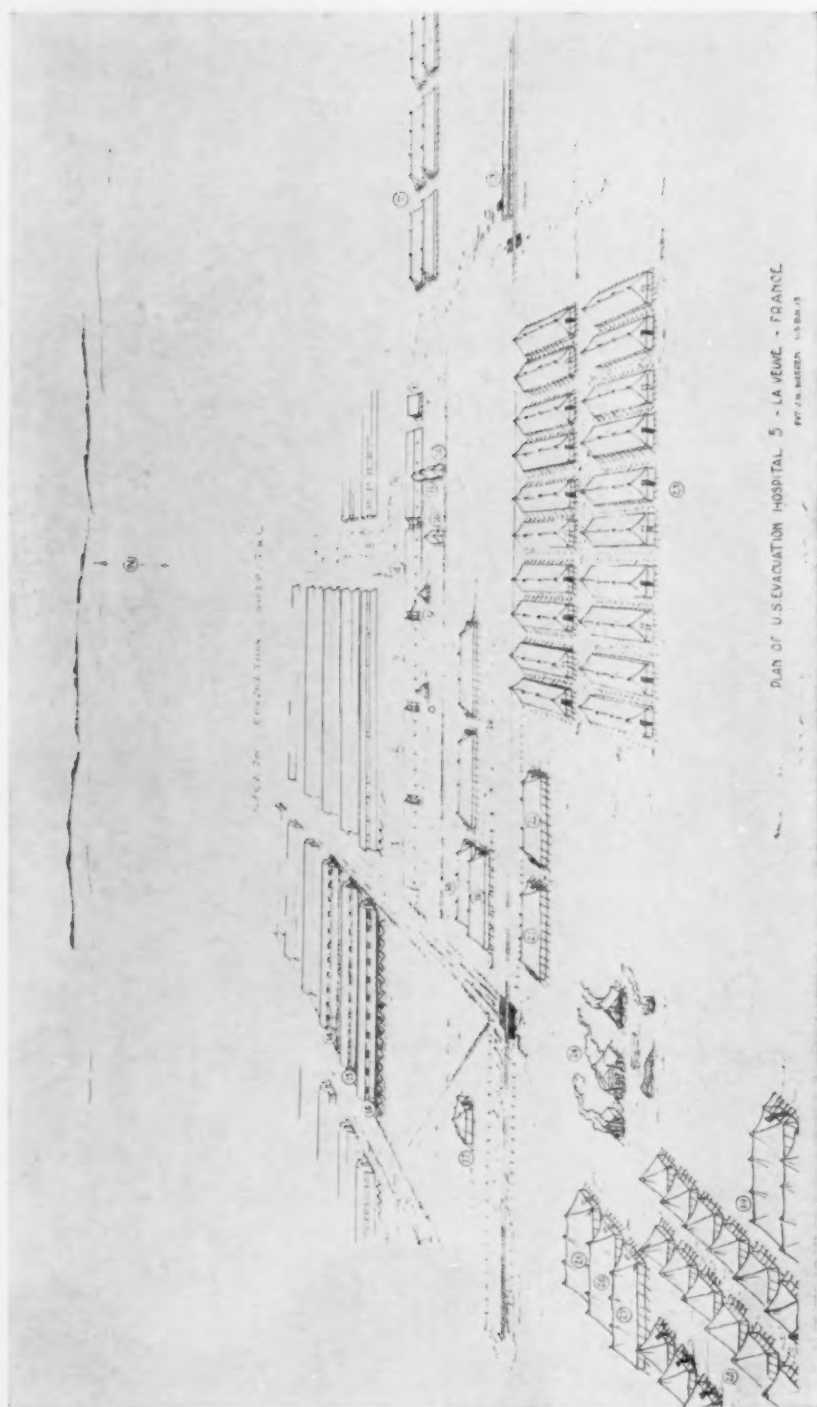


FIG. 2.—Plan of Evacuation Hospital No. 5, La Veuve, France, September 30, 1918. 1, 2, receiving wards; 3, X-ray wards; 4, pre-operative ward; 5, operating room; 6, laboratory; 7 and 23, general wards; 8, X-ray power plant; 9, lighting plant; 10, dentist; 11, sterilizing room; 12, dressing tent; 13, vaccination platform; 14, officers' quarters; 15, nurses' quarters; 16, company officers; 17, Red Cross tent; 18, shock ward; 19, dressing tent; 20, non-evacuatable ward; 21, quartermaster; 22, medical supply; 24, kitchens; 25, officers' mess; 26, nurses' mess; 27, commissary; 28, 29, personnel quarters.

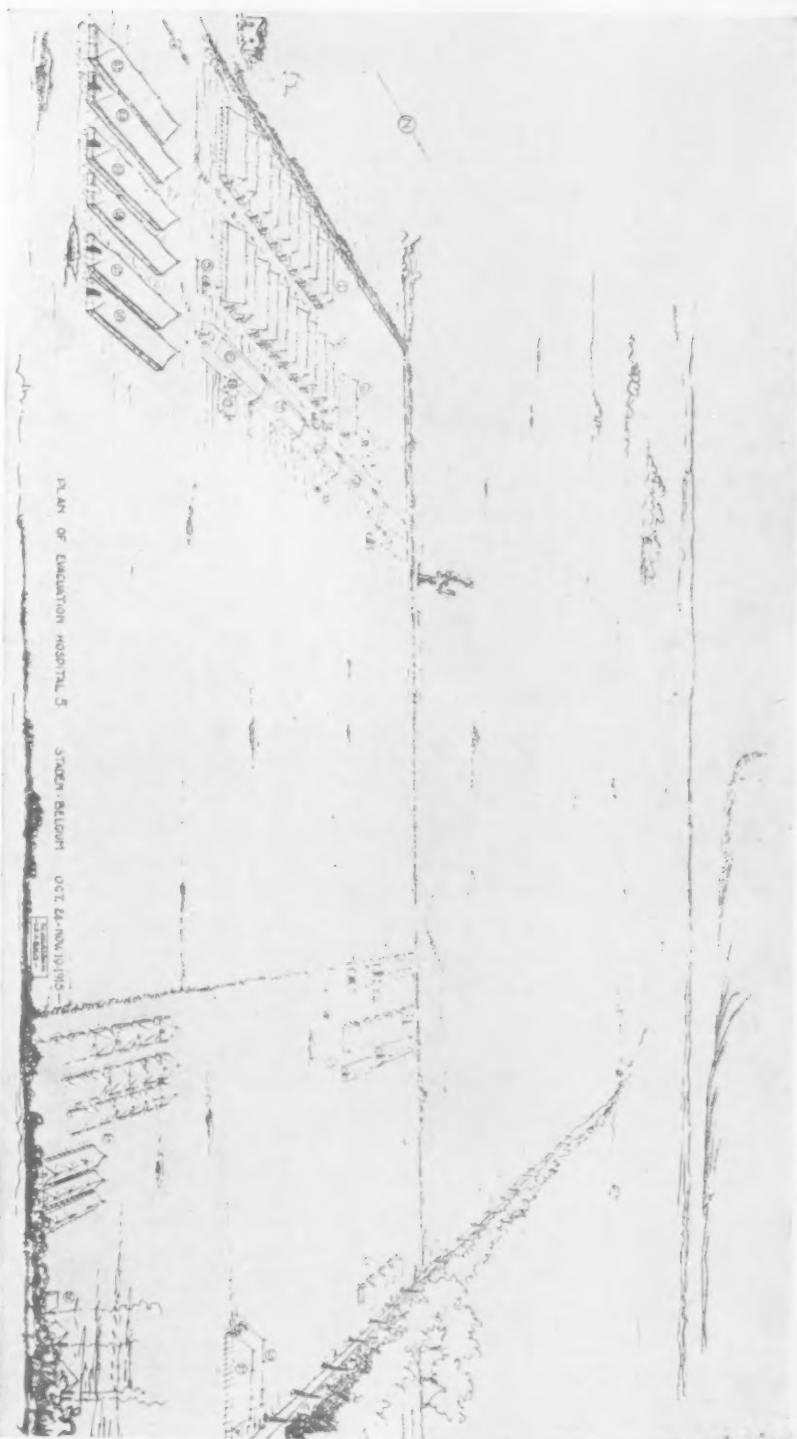


Fig. 3.—Plan of Evacuation Hospital No. 5, Staden, Belgium, October 24—November 19, 1918. 1, 4, 16, 17, 18, wards; 2, shock ward; 3, Red Cross tent; 5, patients' effects office; 6, operating room, Bassonneau tent; 7, pre-operative, Bassonneau tent; 8, X-ray; 9, 10, receiving wards; 11, dressing tent; 12, X-ray power plant; 13, lighting plant; 14, sterilizing room; 15, surgical supply tent; 19, 20, 21 fracture wards; 22, nurses' quarters; 23, 24, officers' quarters; 25, personnel quarters; 26, kitchens; 27, quartermaster; 28, medical supplies; 29, road to evacuating platform.

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the evacuation platform. In the same row as these are placed three tents for fracture cases. These tents are provided with iron beds. All the remaining tents are provided with Gold Medal cots. Seventy-five beds will usually accommodate all the fractures occurring when a division is in action, providing of course that the cases can be evacuated when necessary.

The remaining 14 or 15 tents are placed in two rows on one side of the row of tents belonging to the operating suite. The tents nearest the receiving ward are reserved for medical, eye and ear cases, and the walking wounded requiring shelter. The tents in the middle are reserved for the less severely wounded.

The tent devoted to pathology is placed near the rear of and close by the operating tent, in order that the pathologist or bacteriologist may be close at hand when a bacteriologic examination of a wound is required.

The arrangement of the tents devoted to the administrative staff, to the officers, nurses, enlisted personnel and the quartermaster is demonstrated by the accompanying illustrations. The arrangements of the kitchen and mess tents are also shown.

The arrangement of the tents should be as compact as possible, as the physical demands upon the personnel should be reduced to a minimum. Compactness adds to efficiency.

The following permanently attached personnel is required to run an evacuation hospital of 500 beds with 10 operating tables. During active periods this staff should be reinforced by eight operating teams and a shock team. The teams headed by the surgical chief and his assistant should be permanently attached to the hospital. The permanent personnel should consist of 30 officers. These include a commanding officer, an adjutant, quartermaster, a surgical chief with two assistants, an assistant chief with two assistants, an oculist, a dentist, four X-ray men, a pathologist and 14 ward surgeons. The assignments should be somewhat elastic. At times, a surgical team may be reduced by one, and the man thus released may be assigned to work with more urgent demands—a nurse or an enlisted man acting temporarily in his place.

Physicians, especially trained, should not be sacrificed to duties which men without special training may do as well—often better.

Two medical officers, especially trained in sorting cases, should be assigned to the receiving ward. These officers should work 12-hour shifts. The sorting of the wounded is especially important. The wounded which can be dressed and sent back to the base, form a relatively large proportion of those received. No case about which there is doubt should be sent to the dressing tent, and no wound caused by high explosive should be sent out without an X-ray examination, unless there is no doubt that the fragment of high explosive has not penetrated.

Triage work, well done, relieves the operating surgeon of much work and reduces the amount of work which must be done in the operating room. Thus relieved, the surgeon can give more attention and render better service to those who need it most.

Two medical officers should be assigned to the tent in which dressings are removed and reapplied, antitetanic serum given, and morphine administered when necessary. These officers should each work twelve-hour shifts. They will often have time during the less active periods to work in other parts of the hospital.

X-ray Teams.—Accurate localization of foreign bodies is a *sine qua non* of success in evacuation hospital work. It saves unnecessary, often mutilating, operations. At least three, preferably four, X-ray men should be assigned to each evacuation hospital to operate the two machines with which each hospital should be provided. This is tedious, wearing work, and a man does not work at maximum efficiency much over six hours. If the wounded are not rayed rapidly enough, the work of the operating room is necessarily slowed down. There should be in the pre-operative tent at least 20 wounded, who have been rayed, and the foreign bodies localized. Much time is lost and the general efficiency of the hospital is greatly impaired if at any time operating tables are empty and the surgical teams unemployed because they are obliged to wait for X-ray examination of the wounded. The work is heavy in all active periods. In one offensive, in which the hospital with which we were connected participated, the X-ray men made 1068 localizations in 72 working hours.

It will not be necessary to have an officer detailed to the pre-operative ward; a nurse and two enlisted men should be on duty to see that the wants of the men in the ward are attended to.

SURGICAL CHIEF, ASSISTANT SURGICAL CHIEF AND OPERATING TEAMS.—

Ten operating tables can be easily placed in a Bessonneau tent, which makes the best operating room. Ten teams should be provided in active periods—eight teams being detailed to the hospital when an active period is expected. Better work can be done, if enough teams are available, when they are more or less permanently attached to the hospital.

The Surgical Chief and his assistant should be experienced operating surgeons, and each should take an active part in the operative work. They should take charge of the two tables in the centre of the tent (5 and 6), if the tables are numbered from the entrance of the tent. The chief and his assistant should each work a twelve-hour shift. Working in this way, a surgical chief has first-hand knowledge of the character of the work that is being done, can keep track of those operated upon, thus determining which cases are evacuable and which are non-evacuable; and can act as a consultant. In military, as in civil surgery, the best consultant is the active, operating surgeon. As soon as a surgeon ceases to operate and becomes a directing or administrative officer, his value as a consultant ceases. The operating surgeon, as a rule, will not value highly the opinion of a man who is not actively engaged in surgical work. There will frequently occur, during a shift, relatively inactive periods in which the Chief of the Surgical Service can visit the receiving, pre-operative and shock wards. He can gain in

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this way a rather intimate knowledge of what is transpiring in the hospital.

Surgical Teams.—A surgical team should be composed of seven: three doctors, two nurses and two enlisted men. Such a team can do comfortably the work demanded of them. A surgical team of six—two doctors, two nurses, one anæsthetist, and one enlisted man—can do the work easily.

The operative work is necessarily arduous, and the arrangements should be such that a team can do the maximum of work with the minimum of effort. Their time should be conserved. A time schedule should be put in operation which does not permit of more than eight consecutive hours of work, and provision should be made so that the team can get a full night's sleep—at least every other night. It is absolutely necessary to conserve the energies of the personnel.

An operating team should take charge of two tables. While one operation is being performed, the wounded man on the other table should be prepared. There should be such coöperation between the pre-operative and operating tent that an operating table is never empty. One of the commonest causes of loss of time and reduction in the amount of operative work performed during the day in an evacuation hospital is the lack of coördination between the pre-operative and operating tent. A table empty for a short while means a marked reduction of the amount of work done during the 23 hours that the operating room is active.

The following time schedule, which was operative in Evacuation Hospital No. 5, proved to be very satisfactory. After being posted the officer knew the hours at which his team was supposed to report, and no further notification was needed.

A surgical team on this schedule does not work over eight hours consecutively, and sleeps every other night. The following schedule became operative October 29, 1918, in Staden, Belgium:

	8 A.M. to 4 P.M.	4 P.M. to 12 M.	12 M. to 7 A.M.
Tables 1—2	Major Bailey	Lt. Col. Elting	Major Bailey
Tables 3—4	Major Stewart	Major Drennan	Major Stewart
Tables 5—6	Lt. Col. Lewis	Capt. Noble	Lt. Col. Lewis
Tables 7—8	Major Kocyan	Capt. Zimmerman	Major Kocyan
Tables 9—10	Major Long	Major Ransohoff	Major Long
October 30, 1918:			
Tables 1—2	Lt. Col. Elting	Major Bailey	Lt. Col. Elting
Tables 3—4	Major Drennan	Major Stewart	Major Drennan
Tables 5—6	Capt. Noble	Lt. Col. Lewis	Capt. Noble
Tables 7—8	Capt. Zimmerman	Major Kocyan	Capt. Zimmerman
Tables 9—10	Major Ransohoff	Major Long	Major Ransohoff

This is a most satisfactory schedule for teams can work day after day without tiring. When a team is off duty, it should not be subject to call.

Each two tables should be a unit. Instruments should be provided for each two tables. These should be carried by the Evacuation Hospital and the teams should sign for these to the head nurse when they report to

the hospital. This does lead to a reduplication of instruments, an argument, which might be raised against this arrangement, for each team would be sent out with a separate operating set if it were provided with instruments at a central distributing point. Instruments should be pooled, and this is possible when they belong to the Evacuation Hospital. When pooled, there will be no necessity for a new set up when the teams change a shift. Time will be saved in this way. Each two tables should be provided with an instrument-sterilizer. One large sterilizer for basins and pans will be enough to care for the needs of the hospital.

Fracture Team.—A fracture team of two men should be assigned to each hospital to splint the fractures. These men can save time of the surgeon as they can begin splinting as soon as the operation is finished, permitting the surgeon to start on the next case. The splinting of fractures has become so important that a special training is needed. When the splints are properly applied in the operating room, there is usually but little need for readjustment when the patient is evacuated. The splints are better applied when a fracture team is employed. As patients stand transport so much better when splints are properly applied, there can be no argument concerning the need or usefulness of such a team.

A shock team, if attached to the hospital, should be under the supervision of the most experienced surgeon. Harmony and coöperation should exist between the two. The experienced surgeon is usually the best judge of the condition of the patient and his chances of surviving an operation. The shock team, in our opinion, should be subordinate to the most experienced surgeon to whom these patients should be assigned.

An officer should be detailed at night to have general supervision of the wards. Five officers under him will be able to take care of the work to be done at this time. In case of an evacuation being necessary at night, other officers may be required, but usually six officers can easily perform all the duties required.

Nursing.—Fifty nurses, including the chief nurse and the sixteen nurses assigned to surgical teams, will be sufficient to care for the needs of a hospital such as the one being considered. Twenty-two of these should be assigned to ward duty during the day, and eight during the night. Six nurses in addition to those with the surgical teams are required in the operating room. Three of these should be on a day shift of twelve hours, and three on a night shift of the same length of time. One of these should be a supervisor of the operating room, one an assistant, and the third should have charge of the supplies. But one nurse on a shift will be required to make supplies during an active period, for the supplies provided during a lull should be sufficient to carry the hospital through the next active period. One nurse can prepare the supplies actually required during an active period, if such provision is made.

The remaining nurses are assigned to surgical teams. In some instances, a nurse must serve as an anæsthetist.

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Number and Distribution of Enlisted Men.—Because of the demands made upon an evacuation hospital during the latter months of the war, it was found necessary to increase the number of enlisted men. This was necessary because of the need of taking down and moving the hospital quickly, and of setting it up rapidly when the site selected for it had been reached.

Three hundred and twenty-five enlisted men should be attached to a 500-bed hospital.

The following are the details of enlisted men:

Company Office: Top-Sergeant, 1 typist (Pvt.), 1 orderly (Pvt.).

Quartermaster Department: 1 Sgt. 1st Cl., 2 Pvts. in office, 4 Pvts., 2 truck-drivers, 2 motorcycle drivers.

Salvage tent: 1 Corp., 1 Pvt.

Patients' Valuables and Effects: 1 Sgt. and 1 Pvt.

Medical Supply: 1 Sgt. and 1 Pvt.

Kitchen: 1 Sgt. 1st Cl., 12 cooks, 2 kitchen police.

Laboratory: 1 Sgt., 2 Pvts.

Dental Supply: 1 Pvt.

Dispensary: 1 Sgt., 1 Pvt.

X-ray: 2 Corps., 12 Pvts.

Operating Room: 1 Sgt. 1st Cl., 2 Sgts., 22 Pvts. Total number required day and night.

Overseer of Ward Orderlies: 1 Sgt.

Headquarters Office: 1 Hospital Sgt., 1 Sgt. 1st Cl., 1 Sgt., 1 interpreter (Pvt.), 1 Pvt.

Registrar's Office: 1 Sgt. 1st Cl., 1 Corp., 2 Pvts.

Number Officers and Men in Receiving Ward: Day—1 Officer, 2 Sgts., 1 Corp., 9 Pvts. Night—1 Officer, 1 Sgt., 1 Corp., 11 Pvts.

Sharp instruments should always be at hand, and one of the detachment should be detailed as an instrument sharpener. A large supply of knives should be kept on hand for débridement, which should preferably be performed with sharp knives. Some prefer scissors to the knife for this purpose. Scissors do, however, crush the tissues to some extent. Scissors are to be preferred to a dull knife.

Records.—Two typists should be assigned to the operating room, and when the operation is completed, the description should be dictated. A fairly full, but short, concise history should be given. Many of the histories in evacuation hospitals were so short that they gave no clue as to what had been done. In many instances, they were lost on the way back. The necessity of an accurate, well-written history is imperative. It is only occasionally in U. S. General Hospitals that one can find a record of the type of operation that has been performed. The field medical cards have been taken away en route to the hospital. We have under observation now 9 cases of supposed primary nerve suture. We are certain of but one of these. In this instance, the patient has a typewritten history of the findings at operation and the operation performed, but no field medical card.

The histories are of so much importance and are required so often that we believe that the field medical cards should not be given or attached to

the men. They should be carefully guarded so that they will not be lost and mutilated. They should be given to an officer or private in the hospital train who should see that these cards are delivered to the hospital to which the sick and wounded of his train are assigned.

Technic to be Employed.—Operations should, as a rule, be performed upon the litter. The patient is thus saved the discomfort of moving. After dry shaving, the skin should be cleansed with gasoline. After the gasoline has evaporated, iodine should be applied. This technic, which is simple, proved to be very satisfactory.

Wounds should not be sutured, because of the rapid evacuation. Wounds of the skull or its contents, sucking wounds of the chest, wounds of the abdomen, wounds of the knee-joint, and facial wounds may be sutured. In the remaining cases, the wounds should be left open. If patient could be watched, primary suture might be attempted.

The Evacuation Hospital as an Educational Centre.—In addition to its other function, an evacuation hospital should serve as an educational centre. Because of the opportunity offered in the number of wounded received, and the recent wounds which may be observed, it should serve as a school for developing military surgeons. The officers should first be detailed as observers. They should then become assistants, and afterward, when they have become experienced, they should become heads of surgical teams.

Evacuation hospital work is usually regarded as rough, somewhat careless work. This is a misconception. The surgery done in evacuation hospitals should be done with the same care as traumatic surgery of civil life. Judgment must be developed, and judgment can only be developed when a large number of cases of this type are observed and carefully studied. For those who are to engage in professional work, the evacuation hospital affords many more opportunities for the development of military surgeons than schools established 3000 miles or more from the seat of surgical activity. A thorough review of anatomy should be given at such schools, but the actual work in military surgery should be given in the advanced zone.

Men working in evacuation hospitals should be sent back to base hospitals from time to time, so that they may see the result of their work. By noting failure, they can change the character of the work when necessary, and add to the general efficiency of the work. A close coöperation and interchange of ideas between the officers of the advanced zone and base will add greatly to the efficiency of the service.

A hospital, such as the one just described, should be a mobile unit. One hospital of this kind can take care of the wounded of a division. In one instance that we know of, such a hospital practically took care of the wounded of two divisions.

Ten teams working 23 hours a day should never perform less than 150 major operations. Working at maximum efficiency ten teams should perform 200 major operations. The average number of operations performed by ten teams during this length of time will be about 170.

THE THREE-TABLE MILITARY OPERATING ROOM A PLAN APPLICABLE TO CIVIL HOSPITALS*

By JAMES T. GWATHMEY, M.D.

OF NEW YORK, N. Y.

At the beginning of the war, and throughout its course in some places, each surgical team had only one operating table. In civil hospitals it is almost the universal custom to provide one table for each operating room.

Under war conditions, speed is a necessity; in civil practice it is often quite as necessary and is always an advantage. The utilization of the surgeon's entire time in surgical work is the determining factor in the efficiency of any surgical operating team, and the total output of the operating teams determines the efficiency of the military hospital. The patients come suddenly, in numbers, and require immediate attention. The same may be said to apply, to a less marked degree, perhaps, to civil hospitals. The plan outlined below makes it possible for the surgeon to devote his entire time and effort to the actual surgical work; it doubles, in some instances trebles, his output, regardless of whether he be a fast or a slow operator.

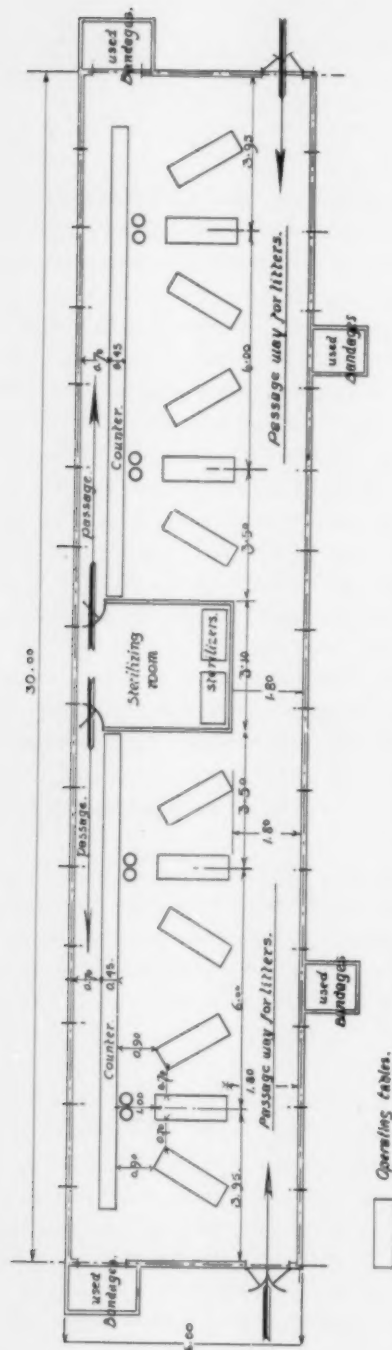
With only one operating table for each surgical team, or in each operating room, after the operation is completed, surgical dressings must be applied, stretcher bearers called, and another patient brought in, anesthetized and sterilized, before the surgeon can begin the next operation. Usually this takes from ten to fifty minutes, twenty minutes being a fair average.

Thus a surgeon, using one operating table, will lose twenty minutes or more between cases, or one hour and twenty minutes of valuable time, in operating on five patients. If these five patients represent a morning's work, in a day's work at least two hours and forty minutes of the surgeon's time will be needlessly lost. This time may be entirely recovered, by making certain changes in the operating-room equipment and technic.

Many British surgical staffs, in the war zone, adopted the plan of having two tables for each operating team. As the dressings were being applied to the first patient, the patient on the second table was anesthetized and then removed—for convenience of sterilization, etc.—to the first table. This saves from five to ten minutes, and is an improvement over the one-table plan. However, if the second operation proves to be a very short one, this time may be lost again before the third patient can be brought in, anesthetized and sterilized, and the operation begun.

The advantage of two tables, with the addition of nitrous oxide, oxygen

* Authority to publish granted by the Surgeon General, U. S. A.



○ ○ ○ Nitrous Oxide and Oxygen Tanks--Large Size with Apparatus attached.

FIG. 1.—Filed hospital operating barrack, American Red Cross, 4 Place de la Concord, Paris, Bureau de Construction, February 9, 1918.

THE THREE-TABLE MILITARY OPERATING ROOM

and ether as the anæsthetic, is shown in the following record of a week's work of one anæsthetist at a base hospital, working with a number of surgeons, and where *speed was not an essential*: September 25, 11 cases; September 26, 17 cases; September 27, 16 cases; September 28, 16 cases; September 29, 12 cases; September 30, 10 cases.

This shows an average of $13\frac{2}{3}$ cases per day of seven to eight hours. The best day, under the same conditions, when *speed was essential*, was 34 cases.

The average for this anæsthetist, working under similar conditions, with chloroform and ether, was eight to nine cases per day. In fact, with chloroform and ether the work was so much delayed that other anæsthetists had to be called in. Environmental technic, and not the anæsthetist, is a contributory factor in the successful dispatch of surgical cases.

The *efficiency problem*, therefore, involves changes in the operating-room technic, in the anæsthetic, and in the surgical team, which have already proved entirely practical for one unit, and which, therefore, can be applied to an entire operating theatre. The changes are as follows:

1. Each surgical team to consist of a surgeon, one anæsthetist, two nurses (one sterile), and two surgical assistants or orderlies.
2. Two sets of surgical instruments, such as are commonly used in all operations, *viz.*, knives, scissors, retractors, artery forceps, etc.
3. Nitrous oxide, oxygen, and ether as the anæsthetic.
4. The surgeon to wash and then sterilize his rubber gloves without changing, add sterile cuffs, and have a sterile towel pinned over gown.
5. Three operating tables,¹ so arranged that the anæsthetic mask can be changed from one patient to the other, *without having to move the nitrous oxide and oxygen tanks*,² and without having to move the tables.

The following plan (see chart), in collaboration with Mrs. Mae Noe Daly, of Autochir No. 7, of the French Army, is drawn to scale, and shows the position of the tables and anæsthetic outfit, by which the surgeon's time can be utilized to the utmost, and full advantage taken of the rapid induction of anæsthesia, and the elimination of the anæsthetic.

No special arrangement of hut, tent, or operating-room is essential in order to utilize the three-table plan. Three tables can be placed anywhere. In the light of our experience, a mobile hospital, with elaborate sterilizing outfit on wheels, and with only one operating table for each surgeon, is an unwise expedient.

I have witnessed eight full teams, each team having only one table, occupied all night with one hundred patients, alternately working and loafing (of necessity, loafing) as each patient was carried out and another brought back, placed on the table, prepared and anæsthetized. The same

¹ Four tables were tried, but no more time was saved than when three tables were used; the fourth table was in the way.

² Only the largest sized nitrous oxide (3200 gal.) and oxygen (1200 gal.) tanks are recommended.

hundred patients could have been operated on more satisfactorily in the same length of time by four teams with three tables each, and the efficiency of four full teams would have been saved for the next day's work.

Soldiers from the battle line, as a rule, show no antipathy toward being placed upon an operating table next to one in active use. (In civil life this aversion may be overcome by preliminary medication, and by placing a towel or gauze over the patient's eyes.) If any interest whatever is shown, it is only a mild degree of curiosity. Usually they have had an unknown quantity, one-half grain of morphia, before leaving the front line. No preliminary medication, therefore, is advisable in an evacuation hospital.

OPERATIVE TECHNIC

The patient on the first table is anesthetized and operated upon. Instruments and sterilization for this table are on two shelves running the length of the hut, immediately to either side of the anæsthetic tanks, and within easy reach of the nurses. While the first patient is being operated upon the second patient is being prepared (as far as his injuries permit) by the second nurse. As the dressings are called for for the first patient, the anæsthesia ceases. *The dressing and bandaging is done by the nurse.*

While the next patient is being anesthetized the surgeon is rinsing and sterilizing his rubber gloves, *without removing them*; a sterile towel is pinned over his gown, and sterile armlets are pulled up and pinned in place. The operation upon the second patient now begins (three minutes or less). Instruments for this second patient are placed on a sterile towel, on a part of the patient's body not to be operated upon. The second operation may, and sometimes does, begin before the first patient is removed from the table.

The first nurse now prepares and sterilizes the third patient. Sterilization and instruments for the third patient are upon a shelf within convenient reach of the nurse. At the proper time this patient is anesthetized, as was the second, the surgeon sterilizing as before, and then operating. By this time another patient has been brought in and placed on the first table. This patient is prepared for operation by the nurse from table two, and the above sequence is followed continuously.

The immense advantage of this plan, plus team work, is shown in the record of a certain team, consisting of one surgeon, one anæsthetist, and one orderly. Starting at 2 P.M., and continuing until 8 P.M., with one hour out for tea, 24 cases were operated upon. It is fair to assume that with two sterile nurses and two orderlies, and utilizing the *entire* time of the surgeon, each team should average 10 to 50 cases per day. Four teams should average 75 to 100 cases per day.

When nitrous oxide and oxygen are not available, the same plan may be followed by adding two anæsthetists to each unit. This insures the even working of the plan.

THE THREE-TABLE MILITARY OPERATING ROOM

While this plan is intended primarily for a casualty clearing or evacuation hospital, it is entirely practical for a base hospital where saving time *for the patient* is not such a vital element. But here some preliminary medication should be given, to insure the even working of the plan.

When morphia is contraindicated, for any reason, "oral analgesia" ³ may be used with assurance. This may be used only in advanced hospitals, regardless of whether morphia has been given previously. It is *especially useful in painful dressings* or slight operations. When employed as a preliminary medication to operation, either with or without morphia, the required relaxation is obtained with much less anæsthetic than when this medication is not used. The "open method" of nitrous oxide, oxygen, and ether may be used when this medication is given.

The method of administration is as follows: One ounce of port wine is placed in a glass, and the "analgesic" in another glass. The patient takes a small mouthful of the wine, holds it about 15 seconds, rinsing the mouth so as to get the aroma in the upper air passages and the taste well established, and then swallows the wine. The "analgesic" is then taken, and is followed *immediately* by the remainder of the wine. Patients are able to take food and water shortly afterward, and even in patients much exhausted by infection there have been no deleterious after-effects. While it is well not to give the "analgesic" immediately after a meal, no special preparation of the stomach is necessary.

The following formulæ have been used clinically with success:

1. Ether,
Liquid paraffin, āā drams iv
Aq. menth. pip. m v

NOTE.—This may be repeated with the port wine as a sandwich in 15 minutes, if necessary. "Rum" may be used instead of port wine, and is preferred by some patients. The analgesic effect is better with rum than with port wine.

2. Ether,
Paraldehyde, āā drams ii
Liquid paraffin drams iv
Aq. menth. pip. m v

NOTE.—Not as pleasant to take as the first mixture, but more powerful, the analgesia being more prolonged.

3. Ether,
Chloroform, āā drams ii
Liquid paraffin drams iv
Aq. menth. pip. m v

NOTE.—A better analgesic effect than the two preceding mixtures, but more apt to be followed by vomiting than the others.

³Gwathmey and Karsner: "General Analgesia by Oral Administration." Jour. A. M. A., April 6, 1918, vol. lxx, pp. 993-995; Brit. Med. Jour., March 2, 1918.

JAMES T. GWATHMEY

SUMMARY

1. By fully utilizing the surgeon's time, the output of any surgical team is more than doubled.
2. Possibility of infection in advanced hospitals due to delayed operation is reduced to a minimum.
3. The number of surgeons in any hospital is reduced by one-half.
4. The plan, with modifications according to the circumstances, may be utilized in civil hospitals as well as military.

BOOK REVIEW

COLLECTED PAPERS OF THE MAYO CLINIC. Rochester, Minnesota. Edited by MRS. M. H. MELLISH. Volume x, 1918, October, cloth, pp. 1196, Philadelphia, W. B. Saunders Co.

These contributions to medical literature from the Mayo Clinic have annually appeared since 1910. That first volume was reviewed in the *ANNALS OF SURGERY* of 1911, vol. liv, p. 718. Again the series was noticed in 1915, vol. lxi, p. 765.

The present book, which is the tenth successive annual volume, commands attention on account of the number of contributors, forty-six in number, and of the number of papers contributed, ninety-five in all. With but few exceptions these papers have been read before medical societies and have already been published in medical journals.

The widely extended territory represented in the various medical organizations thus addressed in a single year, and the medical journals to which the articles thus read have been contributed is most noticeable. The American Medical Association naturally heads the list, and in its journal were published twenty-four of these papers. The Minnesota Medical Societies naturally follow next in order of frequency and are credited with twelve papers which were published in the *Minnesota State Medical Journal*.

Of the more important general medical organizations of the country there appear the American Surgical Association, the Congress of the American College of Surgeons, the American Association of Physicians, the Southern Surgical Association, the Southern Medical Association, the American Society of Clinical Investigation, the American Association of Anæsthetists, the American Public Health Association, the Catholic Hospital Association, the International Association of Medical Nurses, the Western Surgical Association, the Ontario Medical Association, the Saskatchewan Medical Association, the Tristate Medical Association of Washington, Oregon and Idaho, the Medical Associations of the States of Iowa and Illinois, of Montana, Mississippi, Louisiana and Texas, the Chicago Medical Society, the Olmsted County Medical Society, the Chicago Urological Society, and the Clinical Club of the Mayo Clinic.

Of the medical journals in which these papers were published in addition to the two journals already mentioned, the *ANNALS OF SURGERY*, *Surgery, Gynecology and Obstetrics*, and the *American Journal of the Medical Sciences* appear to have been the most frequent vehicles chosen by the authors for communicating with the general profession. In addition to these journals, in some eighteen others one or more of these articles were published.

BOOK REVIEW

The papers are classified into the following sections: I. Alimentary Canal; II. Urogenital Organs; III. Ductless Glands; IV. Heart; V. Blood; VI. Skin and Syphilis; VII. Head, Trunk and Extremities; VIII. Nerves; IX. Technic; X. General.

A large number of the papers, more than half, are brief notes, of ten pages or less in length. Of the more elaborate papers may be mentioned the three papers on various aspects of syphilis, *viz.*: "Syphilis of the Stomach," "The Röntgenology of Syphilis," and "Medical Coöperation in the Problem of War Syphilis."

The paper by Eusterman on "Syphilis of the Stomach" is especially worthy of note and study. It contains data and deductions arrived at in a study of forty cases, in twelve of which the patients came to operation. The composite clinical picture which he draws of the condition is of "an adult averaging thirty-five years of age. Usually the gastric disturbance averages a little more than two years' duration, characterized chiefly by pain, vomiting and flatulency coming on fairly promptly after taking food. The course is progressive, with gastric chemism and X-ray findings more like that of carcinoma. The patient is undernourished, but not cachectic, may be somewhat anæmic, and there is usually absence of any palpable gastric mass. The gastric lesion is invariably extensive, is occasionally localized in the pyloric area, with only a slight tendency to produce stenosis—such characteristics, in conjunction with a positive Wassermann reaction, or with a history of infection and other clinical signs of syphilis, are strong presumptive evidence of specific gastric disease." The important practical bearings of these observations are such as to enlist the interest of every thoughtful practitioner. They throw a light into a hitherto neglected corner of differential diagnosis, and should be supplemented by the studies of practical surgeons quite as much as of specialists in syphilology.

"Clinical Studies in Cutaneous Aspects of Tuberculosis," by J. H. Stokes, is an elaborate and able paper, and supplements materially the discussions of syphilitic conditions. The subject to which most space—fifty-nine pages—is given in this volume is "Studies in Cholesterol," by Georgine Luden. The relation of the cholesterol content of the blood in the cytology of the blood as influenced by food first engages attention, ending in the conclusion that the influence of the food on the chemical composition of the blood increasing or diminishing the amount of cholesterol therein is clearly demonstrated. The important corollary to this is the thesis that "in persons predisposed to carcinoma an increase of the cholesterol and a weakening of the lymphoid defense, such as may occur with the prolonged use of a diet adapted thereto, may perhaps result in the development of carcinoma," and the converse that "dietetic measures calculated to reduce the blood cholesterol and coincidentally increase the lymphoid defense" may yet prove to be of value in the treatment of carcinoma. It is to be hoped that the speculation of the author may bear

BOOK REVIEW

clinical fruit. It is difficult to imagine a more epochal event than would be the demonstration that diet could be made to serve as a curative agent in carcinoma. This paper by Doctor Ludens will give aid and comfort to those practitioners who for many years have claimed to be able to favorably influence the course of a cancer by what they allowed the patient to eat!

The book as a whole bears testimony to the extent and diversity of the work of the Mayo Foundation, which organization is beyond question the most important event in the medical world thus far of the twentieth century.

Though this clinic appears to be a contribution to coöperative medicine, closer analysis shows it to be a wonderful example of individualism in its inception, growth and full development. Medical sociologists may easily differ in the views which they take of the lessons to be derived from and the influence exerted by the Mayo Clinic, while the average practical man remains content to take pride in it and to employ the helps which it is so continuously bringing to him in the solving of his own problems.

LEWIS S. PILCHER.

CORRESPONDENCE

SIMPLE BANDAGE FOR FRACTURE OF THE CLAVICLE

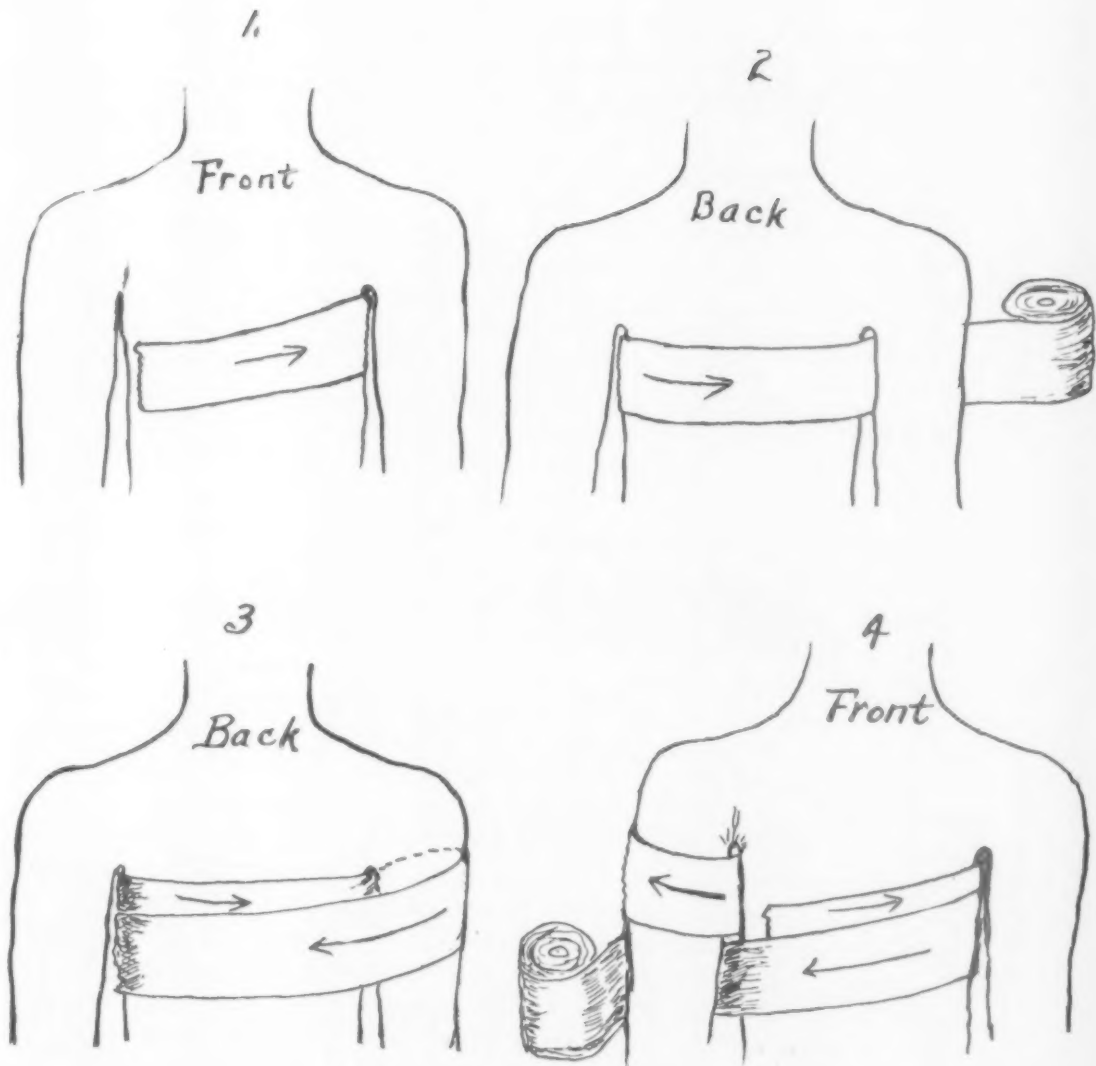
EDITOR ANNALS OF SURGERY:

The bandage described in the accompanying illustrations was evolved during a service in a hospital having a large number of fracture cases coming to the out-patient dispensary. These patients were mainly workmen and children, and it was hard to get them to observe any instructions carrying restrictions on their activity, the result being that they were continually coming back to the dispensary after the first few days of convalescence for redressings. This consumed a vast amount of time and dressing material. To obviate this and to meet the sources of trouble from loosened dressings, soreness and pain over the tendons of the pectoral muscles when the posterior figure eight was used, creasing and pulling over tender areas by slipping adhesives at other times, I began to hunt for some better means of bandaging the clavicle fractures, which seemed to be the most troublesome. One day while attempting to put on a bandage I had read up somewhere a few days previous I got lost before it was half done, but kept at it until at the finish I had put on the one depicted herewith. Its object is to hold the point of the shoulder back, the elbow forward, to allow the forearm to act as a weight holding the fragments down and in place, and finally to completely immobilize the arm and shoulder without binding or discomfort to the patient. A four-inch flannel bandage is used and a single safety pin at the point shown in the last illustration, and passing through all the layers at this point, secures the whole bandage. Under the last turn of the bandage coming down over the clavicle a small layer of cotton or other material may be placed to make whatever holding pressure is desired over the ends of the fragments.

The end results in all my cases were excellent, many patients not returning for two or three weeks, because they had had no discomfort. Whenever there was any tendency of any part of the bandage to crease, a strip of adhesive over the outside at that point after smoothing it out almost always remedied the trouble. Since there is only one smooth layer of bandage over each part, it will be found especially serviceable in hot weather.

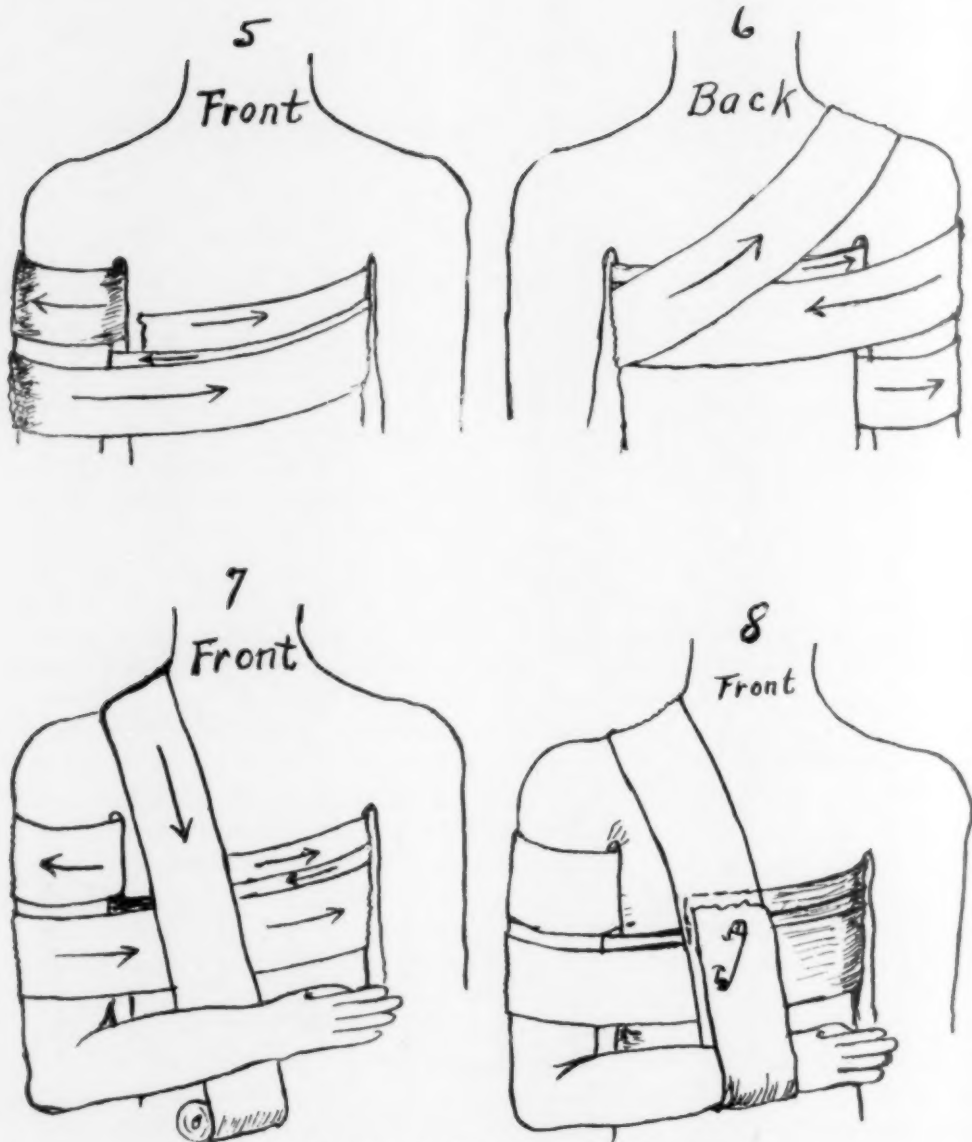
L. A. KENNEL, M.D.,
Lieut., Med. Corps, U. S. Navy.

CORRESPONDENCE



FIGS. 1-4.—Bandage for fractured clavicle.

CORRESPONDENCE



FIGS. 5-8.—Bandage for fractured clavicle.

THE USE OF VEINS AS A REINFORCEMENT
AND SUPPORT OF NERVE SUTURE

EDITOR, ANNALS OF SURGERY:

Most writers advocate the perineural stitch in end-to-end suture of nerves, justly fearing, it seems to me, any traumatism of the nerve bundles distal to the line of suture. A few advocates of the transneural stitch, among them Sherren and Wilms, claim little traumatism to the nerve paths in carrying a fine needle directly through the whole nerve.

The disadvantages of the perineural stitch are: First, that it does not give an absolute, end-to-end, approximation, when the nerve is put under any tension. The very pulling of the nerve together by the perineurium tends to skin the perineurium over the nerve bundles and leaves the nerve bundles short of the ends. When stitched and under tension, the nerve fibres retract and a little gap is left between them. The transneural stitch may certainly overcome this gap, but this stitch traumatizes the nerve fibres. Second, if too many stitches are used at the juncture of nerve ends, the scar tissue is apt to be excessive.

With considerable loss of the nerve substance, from injury or resection, the gap may be difficult to overcome and put the suture under tension. Actually the gap may have to be bridged by the interposition of a fascial sheath, as performed by Dean Lewis, of Chicago, or by a constructed bundle of sensory nerves, successfully performed by Leo Mayer, of New York.

While I have no terminal results to prove my method, more than the immediate application, I venture to suggest the use of veins to reinforce and support the end-to-end perineural suture, to invest the bundles of sensory nerves and support the two lines of suture and as a sometimes substitute for the fascial sheath, to bridge the gap between nerve ends.

Let it be understood that I am aware of the fact that quite a breach between nerve ends can be gained by flexion at the elbow, knee, wrist and ankle, but this in no way contradicts as secure a suture and support of suture of nerve ends as possible.

Moreover, when the nerves are united, there is left a ring made up of the united perineurium and the perineural stitches, which is to come directly in contact with the surrounding scarring in the soft parts, if not involved in bone callus. The scar between the nerve ends can easily mingle with the scarring in the surroundings.

Veins large enough to cover any peripheral nerves, except the sciatic, can be found near the site of nerve suture, near the elbow or knee; the median basilic and median cephalic and branches of the saphenous. The veins easily stretch in diameter to accommodate the nerve. The veins should be taken, preferably, with their connective tissue sheath.

CORRESPONDENCE

Fig. 1 is an attempt to represent, in diagram, a section of a vein investing one of the ends of the nerve to be sutured and about to be pulled over the juncture of the two nerve ends, when united end-to-end by perineural sutures. Four sutures are seen, two at each end of the vein and two perineural stitches, piercing the perineurium of the two nerve ends. Traction sutures are not shown.

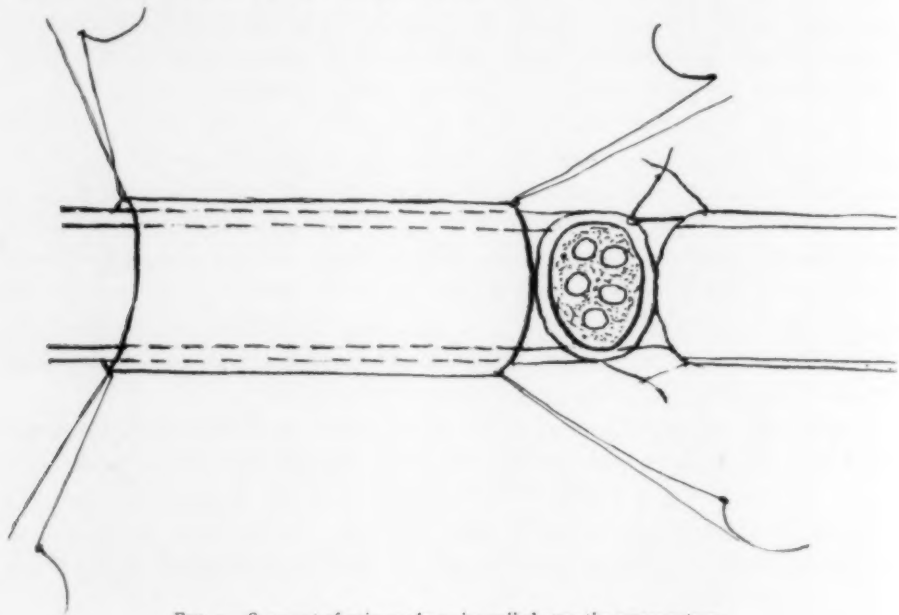


FIG. 1.—Segment of vein ready to be pulled over the nerve suture.

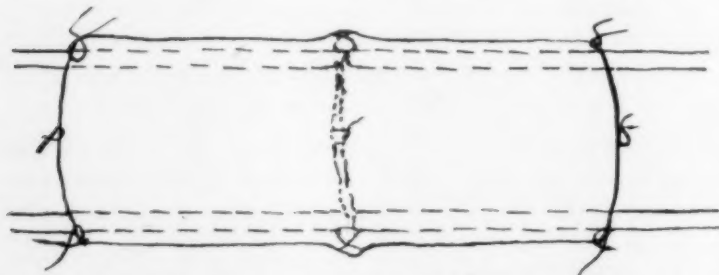


FIG. 2.—The suture completed and enclosed within the vein sleeve.

Fig. 2 would represent the nerve ends, sutured end-to-end by perineural stitches and the vein drawn over the suture line and then attached, proximal and distal, to the line of nerve suture, to the perineurium. All stitches are taken through the long axis of the perineurium.

The procedure is carried out as follows: By means of two, three or four fine silk sutures, the vein is pulled over one end of the nerve trunk, the nerve suture made, the vein pulled over the suture line. The vein is first stitched to the perineurium on one side of the suture line and then,

CORRESPONDENCE

under stretch and at the same time forcing the nerve ends together, the other end of the vein is stitched to the perineurium, on the other side of the suture line. This serves to draw the nerve ends together and put the strain on the vein and perineurium, proximal and distal to the line of nerve suture.

In the same way, the vein, instead of a roll of fascia, may be used to span a gap between the two nerve ends.

If several strands of sensory nerves, united into a bundle, are to be used to span the gap between the nerve ends, the bundle of sensory nerves is first drawn through the vein and both ends of the vein turned back on themselves. Then each end of the sensory nerve bundle is stitched to each nerve end and the two ends of the vein are drawn, up and down, over the two lines of nerve suture and stitched to the perineurium, proximal and distal, respectively, to the upper and lower junctions of intermediary sensory nerve bundle and the two ends of the nerve trunk.

ADDISON G. BRENNER, M.D.

Charlotte, N. C.

A METHOD FOR THE PREVENTION OF HÆMATOMA FORMATION AFTER OPERATIONS FOR UNDESCENDED TESTIS

TO THE EDITOR OF THE ANNALS OF SURGERY:

In operating for undescended testis by any of the approved methods a very frequent, and perhaps distressing complication, is an extensive bleeding from the bed newly created in the scrotum for the reception of the transplanted testis. Indeed, the amount of bleeding—a certain amount is almost sure to occur in all cases—is on many occasions sufficient for the formation of an unexpectedly large hæmatoma, which causes an extraordinary dilatation of the appropriate side of the scrotum, and in the midst of which the contour and outlines of the testis are entirely lost. Under such conditions the period of convalescence is considerably lengthened; and whatever extremely little chance the organ may have for regaining any of its function is jeopardized by the secondary contraction of the gathered blood-clot and a subsequent atrophy.

For a number of years I have arranged my technic in operating for undescended testis so as to eliminate altogether this unwelcome complication. The part of the method of operating by which this is accomplished is carried out as follows: Immediately upon making the customary incision above Poupart's ligament, a passageway is tunnelled subcutaneously from the lower angle of the wound downward into the scrotum to its lowermost part, at which point the transplanted testis is to find its final resting place. The resulting cavity is dilated with dressing forceps and fingers until its dimensions are several times larger than will ultimately be necessary; immediately thereafter it is packed tightly and voluminously with dry gauze. The packing

CORRESPONDENCE

is permitted to remain *in situ* until the termination of the subsequent steps of the operation directed towards curing the usually accompanying hernia, and for lengthening the cord sufficiently to permit the testis to settle without any tension at the lowermost point of the newly-created cavity in the scrotum. By that time the entire operation has been completed with the exception of the closure of the skin incision; and depending on the presence, or absence, of technical difficulties, the packing will have remained in its original position for a variable length of time always longer than fifteen or twenty minutes. The packing is then withdrawn, the testis is slipped into its proper position in the scrotum, and the skin incision is closed. The dressing applied does not include the scrotum.

In the cases in which it has been my privilege to operate according to this method, the postoperative course has never included any hæmatoma formation in the scrotum. The most that I have seen has been a comparatively slight discoloration of the skin, but the scrotal tissues were soft and not infiltrated, the two halves of the scrotum were approximately of the same size, the transplanted organ could be definitely outlined as it rested in the bottom of the scrotal pocket, and the amount of testicular swelling was never more than would ordinarily be expected to follow the necessary handling of the organ.

The packing prevents any bleeding (1) by its mechanical pressure; (2) by allowing sufficient time for the skin capillaries to become occluded by clotting, and (3) by overdistending the dartos so that when the packing is withdrawn a certain amount of contraction takes place.

This technic can be incorporated into any method of operation for undescended testis.

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